New publisher of F. C. W. Vogel in Leipzig. On

the significance

of chemical rays of light for medicine and biology.

Three treatises.

by

Prof. Dr. Niels R. Finsen in Copenhagen. With 6 illustrations and 6 plates. Gr. 8.

1899. Price M. 2.50.

On the application of concentrated

chemical light rays in medicine

by

Prof. Dr. Niels R. Finsen in Copenhagen. With 4 illustrations and 2 plates. Gr. 80. 1899.

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Just published in 1900:

Tenth edition. Prof.

Dr. E. Lesser in Berlin. Textbook of Skin

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is in print

Lesser's textbook is widely distributed and enjoys great popularity. One would not be wrong to consider the reason for this that, in contrast to other larger textbooks, in this case the student and practicing physician are presented with only what they need for practical purposes in the conciseest possible form.

Printed by August Pries in Leipzig.

COMMUNICATIONS FROM

FINSENS

MEDICINSKE LYSINSTITUT

(FINSEN'S MEDICAL LIGHT INSTITUTE) IN COPENHAGEN

I

EDITED BY PROF. DR. NIELS R. FINSEN

THE GERMAN EDITION EDITED BY DR. VALDEMAR BIE, LABORATORY ASSISTANT

AT

THE

INSTITUTE

LEIPZIG

PUBLISHED BY F. C. W. VOGEL 1900

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Foreword to the German edition.

This book is a translation of "Meddelelser fra Finsens medicinske Lysinstitut" I, published in Danish in 1899. Various changes have been made, particularly abbreviations; one work (Some Investigations into the Relationship between Erysipelas and Lupus Vulgaris by V. Eilschou Holm) has been omitted because it lies in the purely dermatological field and consequently has nothing to do with photobiology or phototherapy

In order for the German edition to appear in the most correct language possible, it was necessary for a German physician to correct the translation. In agreement with Professor Finsen, I turned to Dr. Sarason (formerly in Hamburg, now in Berlin), who was the first German physician to practice Professor Finsen's treatment with concentrated chemical light rays. He read through and corrected the manuscript of articles V, VI, and VIII with great benevolence. Since Dr. Sarason in Berlin was unable to deal with Finsen's treatment and was also prevented from continuing the corrections, a

1) Dr. Sarason has, among other things, published his experiences with this method in a lecture (Sarason: On Finsen's Lupus Treatment. Lecture, held at the 20th Meeting of the Balneological Society in Berlin in March 1899. Deutsche Medizinal-Zeitung 1899, Nos. 53-55).

another Berlin doctor, Dr. Theodor Student, who Acquired Sarason's apparatus and set up a Finsen department in Berlin, the correction. The same reviewed Articles Nos. I, II, III and IV. I have compared the translation with the Danish edition and am responsible for ensuring that the opinion of the same is accurately reflected.

Copenhagen, May 1900.

Valdemar Bie.

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Foreword to the Danish edition.

For many reasons, it is preferable to publish the communications and scientific works of the Light Institute in a collected form, rather than scattered across various journals as has been the case up to now. Therefore, this issue will begin a series of "Communications from Finsen's Medical Light Institute."

What these communications will usually be like is best understood from the task, or rather from the tasks, that the Institute has set itself. The first and most essential task is the investigation of light and its effects, for only in this way can a healthy and solid foundation be established for the second task of the Light Institute, namely: the application of light in medicine. The first task requires investigations of a physical, chemical, and biological nature; the second task requires practical medical investigations, experiments on various diseases. Naturally, works will also appear that lie in another field, but which are nevertheless somehow connected with the work of the Institute. On the other hand, works that do not originate from the Institute itself, but which touch on our specific field, can also be included in these communications. Furthermore, it is intended to include critical

To provide analyses and surveys of the entire literature on light.

It is difficult to make firm decisions regarding the publication of these reports, both in terms of time and scope. For the time being, the present material will be published gradually.

Copenhagen, January 1899.

Niels R. Finsen.

Finsens medicinske Lysinstitut.

(Finsen's Medical Light Institute).

In April 1896, a group of gentlemen gathered here in Copenhagen, some of them university professors from the medical faculty and outstanding physicians, and some of men of great influence, whose names are listed below, to create the conditions for a thorough study of the effects of light, with special consideration of their significance for medicine. The reason for this was my investigations into the physiological effects of light, and particularly my demonstration of the powerful influence of light on the course of smallpox, as well as a case of lupus vulgaris that I had cured with concentrated chemical light rays.

It has now been decided to establish a public, independent institution called "Finsen's Medical Light Institute," whose task, according to Section 1 of the statute, is "to conduct and promote investigations into the effects of light on living organisms, primarily for the purpose of applying light rays in the service of practical medicine."

The administration of the Light Institute consists of a senior management and an executive committee. The senior management forms

14 gentlemen, namely the founders of the institute, namely Mayor Borup, President; University Professor of Pathological Anatomy Dr. Carl Lange, Vice-President; Director of the Municipal Hospitals, Justice Counselor Gred-Sted, Secretary; Factory Owner, Candidate Polytechnician Wilh. Joergensen, Treasurer; University Professor of Anatomy Dr. Chievitz; Senior Physician at the Öresund Hospital, Professor Feil-Berg; Factory Owner, Candidate Polytechnician Hagemann; Senior Physician at the Municipal Hospital, Professor Dr. Haslund; Manufacturer, Candidate Polytechnician Juhler; Engineer Niels Mogensen; University Professor of General Pathology Dr. C. J. Salomonsen; Senator WASSARD, Senior Court Advocate, and WINDFELD-HANSEN, Director of the Municipal Lighting System. The Executive Committee consists of the factory owner HAGE-MANN, — President, Justice Counselor GREDSTED, Professor HASLUND, factory owner JÖRGENSEN, Engineer MOGENSEN, and Professor SALOMONSEN. The institute is headed by the undersigned in scientific and medical matters.

Thanks to great kindness from various quarters, it was possible to establish a home for the institute. The Copenhagen municipality donated a building site in the immediate vicinity of the "municipal hospital" and further offered to provisionally provide the institute with electricity and all other resources from the hospital. The Carlsberg Fund approved a sum of 2,500 crowns for the establishment of the laboratory, and the two aforementioned gentlemen, G. A. Hagemann and Wilh. Jorgensen, provisionally advanced the funds for the construction of a building, which was immediately begun, and scientific work began as early as August of the same year. At the end of the year, the aforementioned gentlemen donated the entire construction sum to the institute. However, after just one year, the building as constructed proved to be too small, and therefore, in 1897,

With the help of a state subsidy of 20,000 crowns, a new and significantly larger building was erected, like the first, made of wood and glass, in the style of a studio. While the first building originally contained both a laboratory and an experimental clinic, it was now entirely converted into a laboratory, and the new building housed the clinic exclusively. In addition to these buildings, sunbathing areas, animal stables, etc., were also built.

These buildings had long been insufficient, and the work of the institute suffered greatly from this deficiency; however, conditions will soon improve, as the institute acquired a large property that will be prepared in a short time to accommodate a laboratory, while a clinic must be specially built. Furthermore, it is possible that the institute will receive substantial state aid this year, as a sum of 240,000 crowns will be given to the Lighting Institute as an interest-free loan, in accordance with the proposal in this year's finance law

At the same time as explaining the origins and external conditions of the institute, I will provide some information about the institute's internal facilities and work. As mentioned above, the Light Institute consists of two departments: the laboratory and the clinical department, which are naturally closely connected and mutually support each other.

The clinical department deserves special mention, and some figures from it best illustrate the extraordinarily large growth of the Light Institute over the past 2.5 years. During this period, a total of 333 patients have been treated with concentrated chemical rays; of these, 244 were treated for lupus vulgaris, 89 for other skin diseases as an experiment (the indication for this treatment is superficial, local, bacterial skin infections).

suffer). These patients are distributed over the past period as follows: in 1896, 15 patients, in 1897, 97 patients, in 1898, 221 patients. In addition to these, approximately 30 patients were treated experimentally with photochemical baths

The institute's staff has increased in the same proportion. Now, at the end of 1898, it consists of 7 physicians, 1 physicist, 1 electrician, and 33 nurses, as well as subordinate personnel. The physicians currently employed at the laboratory are: Messrs. S. Bang, Vald. Bie, and V. Siim; at the clinic: H. Forchhammer, Axel Larsen, and Eilschou Holm. Dr. Bang is head of the laboratory, Dr. Forchhammer is head of the clinic. Our physical collaborator is Mr. Candidate Mag. Absalon Larsen. Among our staff, I can also add Dr. Holger Mygind, who has kindly offered the Light Institute his assistance with the numerous laryngological ailments presented by patients with lupus vulgaris

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The following communications have emerged from the Light Institute to date, partly in the form of treatises, partly as lectures or demonstrations; I list them in chronological order:

Niels R. Finsen: Om Anvendelse of koncentrerede, kemiske Lys-straaler i Medicinen. (On the application of concentrated chemical light rays in medicine). Copenhagen, December 1896. (Gyldendals Verlag).

S. Bang: Om Behandling af Lupus vulgaris med koncentreret Lys. Foredrag med Demonstration af Patienter ved det alm. danske Lägemöde i Fredericia. (On the treatment of lupus vulgaris with concentrated light. Lecture with demonstrations

of patients at the general meeting of Danish physicians in Fredericia. August 1897).

Niels R. Finsen: Treatment of lupus vulgaire by concentrated chemical rays. Medical week, December 22, 1897.

Valdemar Bie: On the effect of the various divisions of the spectrum on bacteria. Presented by Professor Salomonsen at the Society of Sciences on April 15, 1898. Oversigt over det kgl. danske Videnskabernes Selskabs Forhandlinger 1898, No. 2, p. 29. (Overview of the proceedings of the Royal Danish Society of Sciences 1898, No. 2, p. 29).

S. BANG: Finsen's Light Therapy. Monthly Journal of Practical Dermatology, Vol. XXVII, 1898.

S. BANG: The Results of Lupus Treatment with Concentrated Chemical Rays. (The Results of Lupus Treatment with Concentrated Chemical Rays). Lecture with demonstration at the 6th Scandinavian Congress of Natural Scientists in Stockholm, July 1898.

VALDEMAR BIE: On the Effects of Light on Microorganisms. (On the Effects of Light on Microorganisms). Lecture at the 6th Scandinavian Congress of Natural Scientists in Stockholm, July 1898

S. BANG: Treatment of lupus by concentrated luminous rays, after Professor Finsen's method. Lecture at the 4th Tuberculosis Congress in Paris. August 1898.

NIELS R. FINSEN: Report for Finsen's Medical Lys Institute. (August 1896 to December 1897). (Annual report) September 1898.

H. FORCHHAMMER: Results of lupus treatment at Finsen's Medical Lys Institute. (The results of lupus treatment at Finsen's Medical Lys Institute). Lecture including demonstration of (approx. 50) patients at the Medical Society in Copenhagen, November 15, 1898

Niels R. Finsen: Phototherapy.
Contents: I. Chemical rays and light. II. Light as an excitation agent. III. Treatment of lupus vulgaire with concentrated chemical rays (Carré et Naud), Paris 1899.

Niels R. Finsen.

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*) The following was published from January 1899 to May 1900:

Niels R. Finsen: On the application of concentrated chemical light rays in medicine. Leipzig 1899. (Vogels Verlag.)

Niels R. Finsen: On the significance of chemical rays of light for medicine and biology. Leipzig 1899. (Vogels Verlag.) (German edition of "La Photothérapie")

NIELS R. FINSEN: Meddelelser fra Finsens medicinske Lysinstitut II (Reports from Finsen's medicinske Lysinstitut II). Copenhagen. December 1899. (Gyldendals Verlag.) Contents:
I. SOFUS BANG: Om Lysets Virkninger paa Mikrober. I. Variationer i Modstandsevnen hos B. prodigiosus efter Kulturens Alder og Temperatur (On the effects of light on microbes. I. Variations in resistance in B. prodigiosus according to the age and temperature of the culture.)
II. ABSALON LARSEN: Actinoskopet (The Actinoscope.)
III. ABSALON LARSEN: Et Fotometer (A Photometer.)
VI. ABSALON LARSEN: Om Buelysets Variation med Ström og Spænding. (On the variation of the arc light with current and voltage.)

SOFUS BANG: Om Lysets Virkninger paa Mikrober. (On the Effects of Light on Microbes). Lecture at the Biological Society in Copenhagen.

VALDEMAR BIE: Remarks on Finsen's Phototherapy. The British Medical Journal, September 30, 1899.

VALDEMAR BIE: Finsen's Phototherapy. The Philadelphia Medical Journal, October 7, 1899.

VALDEMAR BIE: Professor N. R. Finsen's Light Therapy. Journal for Electrotherapy and Medical Electrotechnology, November 1899.

VALDEMAR BIE: Finsen's Phototherapy. Therapeutic Monthly, January 1900.

VALDEMAR BIE: Finsen's Phototherapy. The Medical Week, 1900, No. 3, January 29

II.

New Investigations on the Effects of Light on the Skin

by

Niels R. Finsen.

In several of my earlier treatises 1) I have dealt with the effects of light on the skin, partly mentioning the various works in this field (Charcot, Widmark, Hammer, Unna, Maklakoff, Defontaine, Wedding) and partly reporting my own investigations. Therefore, I will not go into a general description of the effects of light on the skin here again, but will limit myself to reporting and discussing in more detail some experiments, through which I have partly confirmed earlier investigations and partly made new observations.

In December 1896, at the Light Institute, we began working with a very powerful electric arc lamp (80 amps).

1) FINSEN: Om Lysets Indvirkninger paa Huden. Hospitalstidende. July 5, 1893
— On the chemical effects of radiation on dangerous organisms. Hospital Week. November 1, 1893.
— Chemical rays and the varicose veins. Medical Week. June 30, 1894.

are being investigated. Their luminous intensity may be estimated at a little over 40,000 standard candles; for comparison, the electric arc lamps used to illuminate public spaces in large cities usually have a luminous intensity of 2,000 to 4,000 standard candles

At first, when we conducted experiments with the light from this lamp, and before we had learned to be careful, it severely attacked our skin and our eyes, and we all felt the intensity of the light one after the other. Especially on the day after the experiments, the skin on the face and neck was burning warm, red, and sensitive to the touch. The conjunctivae were very strongly injected; one had the sensation of grains of sand in the eyes and was afraid of light. Fortunately, inflammation of the inner parts of the eye did not occur, since we always wear completely black-tinted glasses when we have to look at the arc of light.

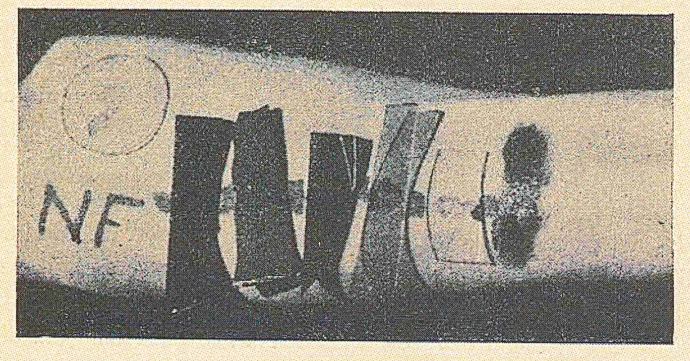
In order to investigate various circumstances concerning this photoinflammation of the skin, and especially to learn what proportion the different types of rays contributed to this inflammation, I carried out the following experiments on my left forearm.

The fact that I made my own arm the subject of my experiment was mainly for the practical reason that observation could thus be undertaken at any time

For the sake of accuracy, I must first state that the skin on my arm was completely white and unpigmented, and that the arm was covered with clothing every day.

Since I was also using the flexor side of the forearm, where the skin is thin, I had an excellent light-sensitive and suitable object for the experiment. The task now was to expose this skin to the strong light of the

80 amp lamp in such a way that certain parts of the skin are affected by all rays, while other parts of the skin are only affected by individual regions of the spectrum. With this intention, I applied to my arm a rock crystal plate, a series of differently colored pieces of glass, some letters and stripes painted with ink, and an ointment whose protective effect I wanted to investigate. All these items and colors were applied to the arm in such a way that the skin surrounding each figure was unrestrictedly influenced by all rays of light; for in this way, the effect of each individual covering object could be most easily observed for the purpose of comparison. After the various items were arranged on the arm, the rock crystal plate and the pieces of glass were adhered with a small drop of fish glue, and the arm was photographed before being exposed to the light.



was. Above, I enclose a print of the photograph; on it, one can see, looking upwards on the arm, near the elbow, a round rock crystal plate (1.5 mm thick), followed one after the other by five oblong pieces of glass (2 mm thick); the one nearest the rock crystal plate was red, the second yellow, the third green, the fourth blue, and the

fifth was an ordinary, uncolored piece of glass. Near the skin, one can see a stripe of the applied ointment. In addition, one can see two letters NF painted with ink, and further, a stripe (a bridge), also painted with ink, between the various pieces of glass

The arm, thus equipped, was now exposed to the light of the 80-ampere lamp, the luminous intensity of which was controlled by an ammeter. The experiment was carried out on the evening of May 11, 1897, and lasted from 8:14 to 8:34 a.m. The arm was held at a distance of 50 cm from the arc, at the position most favorable for the light, i.e., at an angle of 45°-50° along the longitudinal axis of the carbons. Furthermore, the arm was held so that the light fell on the skin as nearly as possible at a right angle

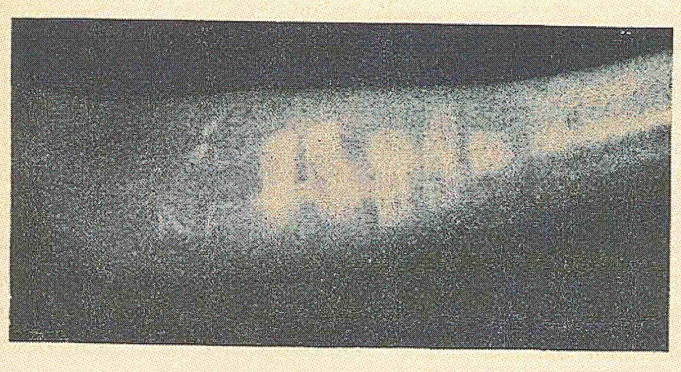
Since the lamp was quite hot, and the experiment would have failed if I had burned my arm, I moved it 75 cm away from the arc after 10 minutes, and then held my arm in that position for another 10 minutes. Then the pieces of glass were removed, and the ink was washed off my arm. The skin immediately appeared somewhat red, even on all covered areas, and equally red everywhere. When examined at 10:12 that same evening, the redness had diminished somewhat, and the skin was still evenly colored overall. When examined an hour later, at 11:30, the redness had increased again, but only in the areas that had not been covered. However, the difference was still very slight, and my experiment book only mentions that the two letters were very unclear

The next morning, however, the result was visible in sharp lines on the skin. It was now dark red and warm and somewhat, but not very, sensitive to the touch

ly. Wherever the skin had been covered with ink during the experiment, it now appeared completely white and normal, standing out sharply against the red surroundings; the two letters appeared very clearly white on a red background. Where the ointment had been, the skin also appeared white, as did where the five pieces of glass had been, with five white stripes of the same irregular shape as the pieces of glass being visible, and the skin of these pieces similarly appeared completely normal. On the other hand, the skin at the spot where the rock crystal plate had been applied had exactly the same color and was just as hot and sensitive as on the uncovered parts. The spot where it had been, however, was clearly indicated by a white ring; the rock crystal plate had not been ground down at the edge, and this uneven edge had scattered the light in all directions, thus preventing it from affecting the skin Furthermore, one could see two patches of almost normal, white skin in the middle of the place where the rock crystal plate had been. I did not immediately understand their origin, but upon comparing it with the photograph taken beforehand, I realized that the isinglass, with which the plate had been stuck, was to blame. The blob of glue may have been somewhat thick, but in any case, it prevented the light from producing a visible effect on the skin. With regard to the glass plates, however, the isinglass played no role, as is clear from the above. The skin was completely the same where the small blobs of glue had been and where the glass alone had covered the skin.

The reddening of the skin persisted strongly for a few days and then gradually decreased. The adjacent photograph, which shows how clearly the effect was noticeable, was taken on May 13 at 3:00 a.m., i.e., two days after the

Effects of light. The photograph was taken on an orthochromatic plate, since the color nuances did not appear quite clearly on an ordinary plate. When the redness had almost disappeared, the skin began to peel off in the form of very small scales, like bran. The peeling lasted several days (from May 20 to 26). The skin then appeared very pigmented, and the pattern visible in the photograph now appeared, if possible even more clearly, white on a brown background.



I noted that at the beginning of August (21% of a month later), the two letters on the arm could still be clearly read. In October, the letters were no longer visible, but the white stripes formed by the pieces of glass could be distinguished, albeit indistinctly

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The experiments reported here coincide in some respects with two earlier experiments, namely by Widmark 1) in Stockholm and by me. Widmark's beautiful

1) Widmark: Hygiea, Festband No. 3

The series of experiments, which I have repeatedly mentioned before and through which it was scientifically proven for the first time that it is the ultraviolet rays of light that cause light erythema, showed how different the effect of light is when it has passed through glass and when it has passed through rock crystal. In none of his numerous experiments did he obtain a photochemical effect on the skin when the light had passed through a glass plate. A glass plate, as is well known, absorbs most ultraviolet rays, while a rock crystal plate allows them to pass through. My experiment has therefore completely confirmed the correctness of Widmark's results

In addition, this experiment partly coincides with one I conducted a few years ago. I painted an ink belt on my arm and then exposed it to sunlight for three hours; as a result, the skin became red and inflamed everywhere, only where the black paint had provided protection was a belt of white and normal skin visible. After a few days, the redness disappeared, and the skin was now pigmented everywhere where it had been red and inflamed. I then exposed the same arm to sunlight again, but without ink, and now the white skin belt became inflamed, while the pigmented surroundings remained unchanged. Through this experiment, I provided evidence of the importance of skin pigment as a protective agent against the rays of light, and thereby answered the often-disputed question of the cause of the black color of Negroes. I have mentioned this earlier experiment in such detail because I find it interesting to make comparisons between the effects on the skin in both cases

1) FINSEN: Hospitalstidende, July 5, 1893, and: On the Significance of Chemical Rays of Light for Medicine and Biology. Leipzig 1899, p. 13.

A comparison may be permissible here, namely that it is the same skin, even the same arm, that has been exposed to two different types of light. I emphasize this in order to simultaneously draw attention to the fact that there are such great individual differences in the skin's reaction to the effects of light that a comparison between two different people would be incorrect

But back to the point: the inflammation that appeared on my skin after exposure to sunlight for 3 hours (the experiment was conducted from 12 to 3 a.m. in the first half of August) was not as severe as that which appeared after exposure to electric light (an 80-amp lamp, a distance of 50-75 cm) for 20 minutes. This superiority of electric light is certainly of great practical importance for light therapy, but it must be remembered that one cannot conclude from this that the electric light was more than 9 times as strong as sunlight; one can only say that it was — more than 9 times richer in ultraviolet rays

My experiment further demonstrated very convincingly the difference between the effect of heat rays on the skin and chemical rays. The heat rays immediately cause a more or less intense redness on the skin. This redness is strongest in the first moment and then decreases. The chemical rays, on the other hand, cause almost no redness at all; it only appears after a few hours and reaches its maximum 12 to 24 hours after exposure. In my experiment, the heat, as mentioned, was very intense for the first 50 minutes, so the skin was immediately very red, and just as red on the areas covered with ink as on the rest of the body

Part; after 2 hours, however, the skin had already become much paler. Thus, the heat rays were to blame for this redness. One hour later, 3 hours after the end of — the experiment, the redness of the skin had increased again; only the areas covered with ink, glass, and ointment were now less red than the surrounding areas, became less and less red, and the next day showed completely white skin, while the redness of the surrounding skin always increased simultaneously, reaching its peak the following day. The chemical rays were therefore to blame for this redness.

The experiment with the letters shows how completely localized and sharply defined the inflammation caused by the chemical rays is.

It is also interesting to see that 20 minutes of illumination could cause such strong and lasting pigment formation that it was still visible after half a year

Finally, there is the experiment with the ointment. This was carried out with the intention of possibly being used by a patient whose skin was particularly sensitive to the effects of light. The ointment consisted of ungventum glycerini colored with evaporated franguladecoct. This was supposed to have a protective effect because of its brown color, which was indeed the case. Incidentally, the ointment was not used, and the interest in the experiment with it essentially coincided with the experiment with the ink drawings.

I did not achieve my intention with the differently colored pieces of glass through this experiment, as the skin under all of them, even under the clear glass, appeared completely the same and apparently completely unaffected. This result showed, as stated above, extremely clearly that the redness that appeared on my skin was exclusively

was due to the ultraviolet rays, as well as the fact that the visible chemical rays had no effect.

Meanwhile, one cannot conclude from this that visible chemical rays cannot cause photochemical inflammation; one can only say that the light used was either not strong enough, or that the experiment did not last long enough. That visible chemical rays, or rather, that light filtered through glass lenses several to one inch thick, can cause photochemical inflammation of the skin, is a daily experience in the treatment of skin diseases with concentrated light, both when using electric light and sunlight. Even if the light, in addition to the four thick glass lenses in the used collecting apparatus, is also supposed to pass through a solution of methylene blue or an ammoniacal solution of sulfuric acid of copper oxide, which solutions absorb most ultraviolet rays, a clear and often severe photochemical inflammation is still observed, followed by pigment formation

Incidentally, to investigate this latter relationship, I also conducted some experiments with sunlight on my arm. I concentrated the light through a rock crystal collecting apparatus, which consisted of a conical metal container, one end of which was closed with a rock crystal lens 10 cm in diameter and with a focal length of 22.5 cm, and the other end of which was closed with a flat rock crystal plate 7 cm in diameter. The intermediate layer of water was 13 cm thick. With this apparatus, the light was collected on the skin, and by holding different colored pieces of glass in front of it, different lights were produced. First, I tried with rock crystal.

alone, then with clear glass, blue glass, green, orange, and red glass, each color for five minutes.

At the same time, the illuminated area was sprinkled with a stream of cold water. In view of the difficult, not to say impossible, task of making all ratios (the percentage light intensity, etc.) the same for all colors, I chose the scale of making the light spot exactly large enough so that I did not feel the heat.

As a result, the spots in front of the different colors became very different in size (from 2-7 mm in diameter).

The result of these experiments was that the skin reacted with the usual photochemical inflammation at the three spots where the light had acted through the rock crystal, the clear glass, and the blue glass, while not the slightest reaction appeared with regard to the other colors. The intensity of the skin reaction followed the same order,

1) The light measurement, which was carried out during the experiment with Vogel's photometer, showed No. 12 after one minute of exposure.

The absorption ratios of the glass pieces were kindly determined by our physical collaborator, Candidate Mag. Absalon Larsen, who informed me the following:

The light glass allows approximately 90% of all visible rays to pass through. A narrow red section was evidently more attenuated, with only 80% passing through. This is where the blue-green tone in the transmitted light comes from.

The red glass allowed 28% of the outermost red rays to pass through, 23% of the middle ones, and 4% of those closest to the yellow ones. All other rays were completely absorbed.

The yellow-red glass allowed approximately 13% red, 5% yellow, and 2% green to pass through.

The green glass allowed a trace of yellow light, approximately 13-15% green light, and very little blue light to pass through

The blue glass allowed 33% of the red to pass through in a narrow section, then almost none of the remaining red; about 3% yellow, 7-8% green, and further increasing evenly to about 40% violet.

was strongest for the rock crystal and weakest for the blue glass. The size of the light spot with respect to these three was as follows: for the rock crystal 7 mm, for the light glass 4 mm, for the blue glass 2 mm in diameter. (For the other colors, the spot was only 2-3 mm in diameter.) I repeated the same experiment on another day with the same result

During these experiments, I observed that the red spots that appeared on the skin rose above its level; they appeared like flat, hyperemic spots whose edges rose sharply above the normal skin. At the same time, I must add that no blisters formed, so no detachment of the epidermis was responsible for the elevation.

The experiments reported here not only confirm the results obtained by Widmark, they also expand on them.

I will, however, return to the first experiment with the light from the 80-amp lamp on my arm. This experiment was of great importance for

1) The method I chose here, making the spots so small that I couldn't feel the heat, apparently doesn't look as good as if, for example, I had made all the spots the same size; in fact, however, the latter would have been much more inaccurate due to — the different absorption ratios of the glass pieces. It is quite interesting to note from the results that the reaction was strongest where the conditions were apparently most unfavorable (when the same amount of light is concentrated on a large spot, the conditions are naturally less favorable than where it is concentrated on a small spot). In the experiment with the rock crystal, the light spot was 7 mm in diameter, and here the reaction was strongest; for the green, orange, and red glass, the spot was 2-3 mm in diameter, and here no reaction occurred at all. Incidentally, I must point out that I only consider these experiments to be of significant value in answering the question of whether it is exclusively the ultraviolet rays that cause the photochemical reaction on the skin.

me when I became aware of the remarkably strong effect of ultraviolet rays and the great importance it would consequently have for light therapy with concentrated light to use collecting apparatus with rock crystal lenses instead of glass lenses. One must assume that the ability of light to induce inflammation, in addition to its ability to kill bacteria, is of great importance for therapy. However, since I saw the severe inflammation of the skin beneath the rock crystal plate, an inflammation that was apparently just as severe as on the uncovered skin, I wondered whether ultraviolet rays might also have a correspondingly powerful effect on bacteria. 1) Therefore, I conducted some experiments with light through a collecting apparatus with rock crystal on a culture of Prodigiosus sown on a rock crystal plate This was followed by the demonstration of an extraordinarily great bactericidal ability of these rays. A more detailed investigation of this relationship, along with the ability of the other radiation qualities to kill bacteria, was carried out by my assistant Dr. Bie, to whose excellent investigations, presented in this book, I would like to refer.

I made yet another observation following this simple 20-minute experiment on my arm. I mentioned above that approximately four months after the experiment, the skin was so pigmented that the white stripes formed by the glass stripes were indistinctly visible. A few months later, they were no longer visible, and the skin on the arm was completely uniform in color, with no markings.

1) As I already mentioned in my treatise: On the Application of Concentrated Chemical Light Rays in Medicine, p. 6, opinions on this matter have been very different to date

One morning, however, as I was rubbing my skin as usual, I noticed that the pattern on my arm reappeared, so that the parts of the skin that had been protected by the glass strips did not become as red as the surrounding areas due to the rubbing. This can only be explained by the fact that the dilation of the capillaries and vessels of the skin, which is a result of the effect of chemical rays on the skin (I had previously examined this microscopically on the tail of the tadpole), 1) was partially maintained, so that it was still detectable 5-6 months after its induction, and even after the skin pigment had disappeared

This dilation of the skin capillaries, whether called pathological or normal, appears, although hardly to such a high degree as here, through any reasonably strong exposure to light on the skin; and that it has a certain beneficial effect on the skin is beyond doubt. One could well assume that more blood flows to the skin, or that this would at least be possible, when the capillaries are dilated, and furthermore, that the skin is better nourished and consequently becomes more functional again. 2)

If it is the case that a frequent but not so

1) FINSEN. Hospitalstidende d. November 1, 1893

2) In this context, I would like to draw your attention to some older, very interesting studies by Berthold. He found that nails grow faster in summer than in winter. The same nail that needs 116 days to renew itself in summer needs 152 days in winter. Hair growth is also more abundant in summer than in winter, and during the day than at night. (Müller's Archives for Anatomy and Physiology 1850, p. 156). That this is true with regard to beard growth, and that the difference is quite significant, I have received confirmation from various barbers through inquiries. They declare it a fact well known to all barbers that one does not need to be shaved as often in winter as in summer

Since intense lighting has the same effect on the capillaries of the skin, we must expect a greater blood filling, or the ability to fill with blood, in those parts of the skin that are daily exposed to light than in those parts that are always covered by clothing, and this is indeed what we find.

The face, neck, and hands of most people are, as is well known, of a much stronger color than the rest of the skin, and there is often a very sharp color boundary between the covered and uncovered skin. That this is not only characteristic of the face, neck, and hands, but of the skin in general, can be clearly seen in children and in people who walk with bare arms and knees; the skin color always changes right up to the area covered by clothing.

This strong color is, of course, largely due to the skin pigment; but it is usually easy to see that a considerable part is due to a more abundant blood supply

In albinos, the blood is solely responsible for this skin redness, and in very blond people, it is almost exclusively the blood. In autumn and towards winter, when the skin pigment begins to fade, it also becomes clear that the blood supply plays a major role in skin color, even in more pigmented people. Incidentally, even if the skin is very pigmented, one can usually see whether the pigment alone or also the blood supply is to blame for the skin color. If, in addition to the pigment, there is abundant blood supply to the skin, it appears a warm, reddish-brown color; if, on the other hand, pigment is primarily responsible, the color is grayish-brown and cold. This is often observed in the same person at different times.

This reddish color of the skin described here can

can probably be considered such a constant phenomenon that it can be considered a fact that the part of the skin that is not covered and which (at least in summer) is exposed to light and air in a normal way will acquire a more intense red color than the covered skin. Special conditions apply to the cheeks; these are very often red, even when the rest of the facial skin, which has been exposed to the same external influence, is completely white. The red color of the cheeks must therefore be considered something special, a racial peculiarity

Meanwhile, it does not follow from this, although it seems from my light is to blame for this skin redness. — investigations that According to the previously accepted view, one would rather say, at least with regard to the particularly strong forms, e.g., the complexions of sailors and landowners, coachmen, and generally people who spend a lot of time outdoors, that wind and weather are to blame. Analyzing wind and weather, however, is not so easy, because even if light is included, i.e., in the form of heat (identical to the expression "sunburnt"), one still largely thinks of air and water, especially in the form of storms, rain, or snow (identical to the expression "weather-beaten")

One can assume that rain and wind work primarily through the cold or warmth they possess, but to a much lesser degree they work mechanically through the force that acts on the skin, whipping it, so to speak. While we can therefore safely disregard the mechanical moment without harm, the relationship is quite different with cold and warmth.

The powerful influence of cold and warmth on the expansion and contraction of the vessels and capillaries

are phenomena that have long been known and irrefutable. Their significance for this question will therefore generally hardly be underestimated, whereas it will be more difficult for light, which has so far been treated so neglectfully, to have its contribution to this phenomenon recognized. The situation here is the same as with two other phenomena caused by light: the formation of pigment in the skin and solar erythema. It was believed that "wind and weather" were to blame for the pigment formation and that solar erythema was caused by the sun's heat; but now we know that the chemical rays of light are to blame for both phenomena

According to my observations, chemical rays have the ability not only to cause the already well-known acute redness of the skin, but also a permanent dilation of the skin capillaries. On the other hand, there is hardly a more well-known phenomenon than the strong redness that appears on the skin after exposure to both intense heat and intense cold. Precisely for this reason, however, analyzing how large a share in the skin redness 1) one or another of these three agents has is very

1) When mentioning physiological skin redness, one must not mention the interesting "blushing," which is due to psychological causes. In Darwin's *The Expression of the Emotions*, 1872, where blushing is made the subject of investigation, there are several things of interest to us. Darwin says (p. 315): "It is an interesting question why only the face, ears, and neck mostly become red, although the sensation and feeling of warmth often extends over the surface of the whole body. This seems to depend mainly on the face and adjacent parts of the skin having been habitually exposed to air, light, and changes of temperature, whereby the small arteries have not only become accustomed to being slightly dilated and contracted, but they also appear to be unusually well developed in comparison with other parts of the surface. This opinion is, moreover, confirmed by the fact that certain races which go almost naked often blush on the arms, chest, and abdomen."

be difficult, since an isolated effect cannot be easily carried out.

If I will attempt such an analysis in the following, it is not because I underestimate the difficulties involved (it is especially important to remember that agents other than the three mentioned here may also have an influence), but because I can thereby make other contributions to the solution of the question. Let us first consider the reddening of the skin caused by heat, of which we can probably establish two types: a direct and an indirect

One, the direct one, is "heat — erythema," which is caused by the local exposure to intense heat. It is based on a paralysis of the muscles of the skin vessels and, in contrast to light erythema, appears immediately after the exposure and, likewise in contrast to light erythema, disappears very quickly, depending on the intensity of the exposure, sometimes after a few minutes, sometimes after a few hours.

Heat strong enough to cause such erythema does not exist in the medium surrounding us, at least not in our climate, so we can completely disregard it when we sprechen.com of the natural redness of the skin

The other type of redness of the skin, which can arise from the effects of heat, is of greater importance to us; it appears when the heat of the body becomes too great, either due to the heat of the surrounding air or due to increased heat production within the body itself, and the blood rushes to the skin. Now, one might think that if this process were repeated very often, a permanent redness of the skin would appear. This, however, is not the case; the opposite seems to be true

something we can see in people who are particularly exposed to greater heat, e.g., bakers, stokers, metal founders, whose pale complexions are characteristic. Europeans who settle in the tropics are also said to usually develop a pale or sallow complexion, although their skin becomes more pigmented.

We therefore see that heat mostly seems to play a negative role in the etiology of skin redness.

The relationship with cold seems to be different. The first phenomenon when the skin is exposed to cold is, as is well known, a contraction of the skin muscles and vessels, so that the skin turns white; But later, especially after a long and intense exposure to cold, a reactive, strong reddening of the skin appears, the duration of which corresponds somewhat to that of the heat erythema (since all can usually be calculated in minutes or hours, in contrast to the light erythema, whose duration must be calculated in days). While the reactive reddening of the skin itself quickly disappears in each individual case, it could happen that frequent repetition of this process—in contrast to the heat exposure—produces a permanent red color of the skin. I cite, for — example, the complexion of coachmen — and sailors in winter. The same parts of the skin that are under the influence of cold are, however, also exposed to light, which makes it difficult to determine how much is due to one factor and how much to the other.

We know that strong light, even without the aid of cold, can produce a fairly permanent redness (light erythema).

1) C. LANGE: Almindelig patologisk Anatomi. 1896. P. 60.

can; but that even frequent exposure to not so strong light, without erythema ever having been present along with — pigmentation, can produce a reddish color of the skin, I have often had the opportunity to observe after sunbathing and electric (photochemical) light baths, which we use in the Light Institute. To what extent, on the other hand, cold can produce a permanent, normal reddening of the skin without the mediation of light is more difficult to determine. Since it must be considered irrelevant whether the cold acts in the form of cold air or cold water, one could perhaps expect to gain some insight into this by examining the effect of frequent cold baths, e.g This has been observed, for example, in cold plunge baths or especially cold foot baths (since these require prolonged exposure to cold). As is well known, however, the skin does not acquire a significant, lasting red color, at least not a color comparable to that of uncovered skin. However, with these baths, the relationship is such that the skin is covered by clothing between exposures to cold, which could possibly make a difference, and for this reason, they can only be compared with the light baths, whose effects on the skin I just mentioned.

On the other hand, one might also be able to learn something about the uncovered parts of the skin by examining how North Pole explorers fare, who are exposed to very severe cold and, at the same time, have to live in the darkness of the polar night for several months of the winter. It is fortunate that some studies on the color of skin after wintering have just been published from a polar expedition; namely: "Undersökningar till förklaring af hudfärgens anmärkta förändring efter öfvervin-

Investigations into the explanation of the perceived change in skin color after wintering in the polar regions, carried out during the last Swedish expedition to Spitsbergen by their physician R. Gyllenkreutz and communicated by Frithjof Holmgren. (Upsala läkareförenings förhandlingar 1883-84, p. 190).

Holmgren writes: "Those who took part in the earlier winterings in the polar regions have often perceived a changed skin color as a peculiar phenomenon, which appears when daylight returns after the long winter night and which gradually disappears again

It should suffice here to cite a few comments on the observed effects of the winter night as daylight approached. 1) Kjellman describes the relationship as follows (translated from Swedish): "How bright we found it outside in the first days of February, and how strange it seemed to be able to clearly distinguish the surrounding objects again in the open air, to see ourselves and the comrades standing or walking nearby. We also observed each other with great attention. We had all, of course, undergone changes in the past time. With our yellow-pale, flabby, emaciated, bearded faces, we no longer resembled the same people from the summer; the influence of darkness was clearly and distinctly evident!" In the doctor's report, which Kjellman 2) cites, it says:

1) F. R. Kjellman: Swedish Polar Expeditions 1872-73 led by A. E. Nordenskjöld, p. 226.

2) Cited in the same book: pp. 232, 233.

about the same: "The winter climate in Spitsbergen, which in terms of severity cannot be compared by a long way with that of the North American Archipelagus or Siberia, could, on the other hand, be considered less healthy due to the prolonged low temperature, the frequent storms and snowstorms, the strangely rapid changes in the weather, and above all, the unbearable darkness. The effects of these varied somewhat from individual to individual. In some, drowsiness, indifference, and weariness developed; in others, a striking irritability of the mind with a generally strong moodiness; some complained of sleeplessness at night and great tiredness during the day; and in all, without exception, a more or less pronounced chloroanemic condition developed. When the sun returned, the prevailing complexion was pale, bordering on yellow-green, like that of plants grown in a dark room with insufficient light. Another effect of the long Arctic winter, which which could be indirectly attributed to the darkness, and which depended more directly on the anemic condition, was a generally prevailing dyspepsia, a kind of atony of digestive efficiency," etc.

As can be seen from this, the altered skin color, which Kjellman describes as "pale yellow" and the doctor as "pale, bordering on yellow-green," seems to be a constant consequence of overwintering, and which, based on the statements cited, of all the contributing factors, is mainly attributed to the influence of the darkness.

Holmgren next recounts how, in Uppsala, during a discussion about this altered skin color, the remark was made as to whether it might not possibly be a subjective phenomenon and due to a change in the color sense in the patient

observer, caused by the fact that the eye had to go without daylight for so long. Therefore, it was decided for the upcoming expedition to Spitsbergen to investigate the extent to which the change in skin color was an objective or subjective phenomenon. The investigations were carried out by the doctor Gyllenkreutz in such a way that, upon the return of the sun in spring, one of the expedition members was to remain continuously in the dark until the skin of the other members had regained its natural color. The engineer Andrée volunteered to participate in this painful experiment. Gyllenkreutz wrote about it in a report (written in March 1883 on Spitsbergen): "January 24, 1883, was the first day on which a greater twilight appeared. Mr. Andrée (AÉE) had willingly offered to remain in the dark and artificial light until the rest of us had acquired a normal color through daylight. He began his torture that same day

On February 21, the light corresponded to an ordinary winter day in Sweden. We observed the sun from a 1,500-foot-high mountain. At noon, a general examination was made, and the complexion of each participant was determined by all the others, and the person concerned could check their judgment in a mirror. The verdict was unanimous: they all had a white, already delicate, slightly pink color, rosy-tinged, as one might say. Only one person (EM) had a very slight nuance of yellow-gray on the nostrils. Then AEE came out and had to first pronounce on the color of each individual, and his judgment was entirely in agreement with ours. Then he was compared with the others in turn, and we all found, including himself (through the mirror), that his color varied quite a lot in the

yellow-gray, although he had pretty pinks on his cheeks

I have reported on these examinations in considerable detail because they are very peculiar and of great interest for the question being discussed here. It turns out that everyone, even Andrée, had "roses on their cheeks," and while Andrée's complexion was somewhat yellow-gray, all the others had a white, albeit delicate, color, somewhat shifting into red. In another passage where the details of the assessment are mentioned, the expressions "he was pale like a city girl," "white," and "red, just like a delicate city lady." If one disregards the cheeks, for which, as previously stated, very special conditions apply, one is undeniably somewhat astonished that these people, who had been exposed to the excessive cold and unfriendly weather of the polar regions for an entire winter, all had a "white, almost delicate color." Of course, we must not forget that these people may have had some anemia; according to Gyllenkreutz's statements, however, it was only to a slight degree.

Be that as it may, these investigations do not indicate that cold alone plays a major role in the appearance of skin redness. However, since we see every day that people exposed to both cold and light develop a very deep red skin color, especially much more so than those exposed to sun and warmth, it does not seem unreasonable to assume that cold promotes or supports the appearance of the skin's red color

Finally, I will briefly recapitulate and clarify what was achieved through these investigations.

1) The accuracy of Widmark's investigations into the effect of light on the skin has been confirmed and further expanded in that visible chemical rays also have the ability to induce the peculiar photochemical inflammation.

2) It has been proven that in electric light, the strongest bactericidal ability belongs to the ultraviolet rays, and as a practical result of this phenomenon, the necessity has arisen to use exclusively quartz lenses for electric light-collecting devices; and this change has led to very great progress in treatment with concentrated light.

3) I have demonstrated that the expansion of the skin capillaries caused by chemical (ultraviolet) rays is long-lasting, and it has been macroscopically detectable approximately half a year after exposure to light

4) A compilation of the various factors acting on the skin has shown that the normal reddish color, which every skin gradually acquires when not covered, owes its origin, if not exclusively, then at least to a great extent to light, i.e., to the chemical rays of light. The development of the reddish color of the skin appears to be inhibited by the effect of heat and promoted by the effect of cold.

For the study of the physiological effects of light, the demonstration of points 3 and 4 represents a good step forward. For whereas previously, when discussing the effect of light on the skin, only acute reddening of the skin was recognized, and pigmentation was considered the most essential or sole chronic effect or consequence of light exposure, chronic reddening of the skin has now been added as a phenomenon that is also due to light exposure.

The reason that this chronic effect of light has been overlooked so far is undoubtedly that the simultaneously occurring skin pigment has usually been noticed and occupied all attention, as well as the fact that the pigment partially covered the red color of the skin. On the other hand, in cases where only very little pigment was produced and therefore a distinct reddening of the skin, or where the pigment disappeared and the reddening of the skin became more apparent, this effect has usually been attributed to factors other than the chemical rays of light

So we have taken a step forward, but the step is not complete because we do not sufficiently understand the importance of an abundant blood supply in the skin. We can conclude from this that the skin is better nourished and can perform its functions better; however, we do not yet know exactly what these functions are. Only when we know these will the significance of the effect of light become clear to us, and we will then certainly have to acknowledge at the same time that in the chemical rays of light we have a means—perhaps the most powerful we have—to help the skin's functions through 3

the use of light baths. Finsen's Medical Light Institute,

At the Light Institute, we have been conducting some experiments for some time—but essentially for a different reason—with the therapeutic use of such photochemical light baths (sunbaths, electric light baths). However, our material has been somewhat limited so far, and we have not yet progressed beyond the experimental stage.

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1) By these, I naturally do not mean the incandescent light baths or weak arc light baths that have been so widely used recently, but rather very strong arc light baths (100-ampere lamps). See, incidentally, my remarks on light baths: On the Significance of the Chemical Rays of Light for Medicine and Biology. Published by F. C. W. Vogel. Leipzig. 1899. Pages 69-71.

III.

An Electric Incandescent Light Thermostat

by

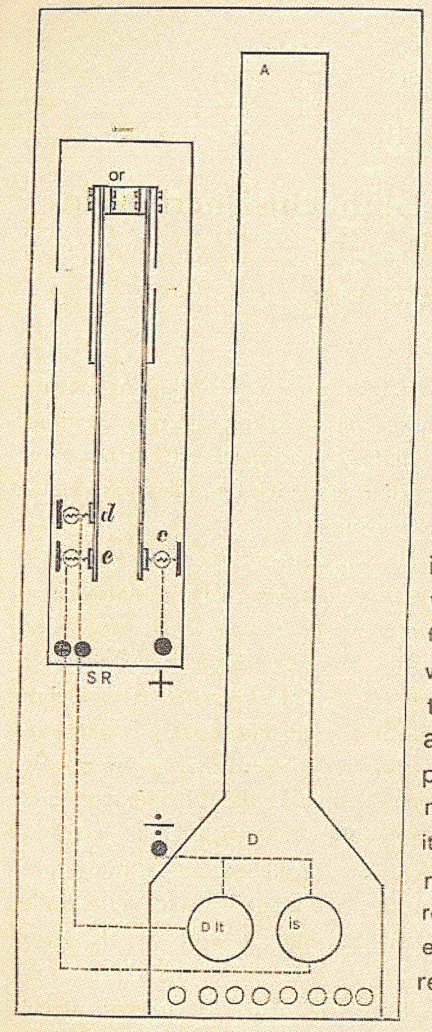
Sophus Bang

Where electricity is available in the laboratory, as I will discuss in more detail below, there are certain advantages to heating the thermostat by means of an electric lamp. To make this possible, I have constructed the following electric thermoregulator.

In principle, it consists of a spring formed by two soldered-together strips of metals with different coefficients of thermal expansion (e.g., steel and brass or steel and zinc). One end of the spring is fixed, and the other carries a small platinum plate on the brass side, which rests against a screw tipped with a platinum tip. The current from the lamp passes through the spring and this platinum contact; as soon as the temperature reaches a certain level, which depends on the position of the screw, the contact is broken due to the greater expansion of the brass, and the lamp goes out; as soon as the temperature later begins to fall, the contact is re-established, and so on

This simple device, which any mechanic can easily make, works very satisfactorily. Each push-

wooden box can function as an improvised thermostat. For years, such a thermostat has been in continuous operation at the



Light Institute. The manufacturing costs for the regulator (including the light bulb) amounted to approximately 8 marks, and the thermostat box (a very simple wooden cabinet, 30 x 30 x 65 cm) cost about the same. The accuracy of the regulation is approximately 12 °C as the largest deviation; for days, the temperature barely fluctuates by 1/50. B A

nevertheless a disadvantage that the incandescent lamp, as is well known, only functions for a certain time; if one wants to be absolutely sure that the lamp will not fail after a few months, perhaps at an undesirable moment, one must replace it more often than otherwise necessary. Partly for this reason, and partly to achieve even greater accuracy and reliability of regulation,

I later had the regulators, which are now also in use

in various other laboratories, set up in the following way.

Two springs (A and B) are attached to a slate plate SS

Spring A has its brass strip on the right, spring B has its left. Near the tip, A has a platinum contact for screw c, B has two for screws d and e. These three screws all have platinum tips. The current enters at , passes through contact c, spring A, spacer m, spring B, and divides at d and e into two branches, each for one of the two light bulbs D and E, after which it exits through the thermostat.

To set this regulator for a specific temperature, say 37°C, one first screws d and e quite far to the right, so that even at too high a temperature these contacts are not broken. C is now set so that the lamps (both simultaneously) go out at, say, 37°C. Now that this temperature has remained constant for a few hours, one turns back screws d and e enough so that the temperature now remains at 37°C These screws can easily be adjusted so that when the thermostat door is opened, lamp E lights up first, followed two seconds later by D. The two contacts d and e actually only take care of the regulation, while screw c, which is set for 37.5°C, always remains in contact. This latter thus serves as a safety device; should one day (which has never happened to me yet) d or e not interrupt the current at the right time, e.g. due to dirt, c already comes into action at 37.5°C. C also has another use. If one wishes to temporarily work at a temperature lower than 37°C, one can very easily set the desired temperature using c, without having to worry about dunde. As soon as one returns to

If one wishes to return to 370, one simply turns it closed again, rather a little too much than too little; d and e then immediately assume their old role without having to worry about setting it to 37°C again.

If, as discussed above, e closes the contact a moment earlier than d, with the thermostat door closed, only e (with lamp E) will function, with E igniting and extinguishing several times a minute. However, as soon as the door is or was opened, both lamps burn simultaneously due to the greater cooling, and the desired temperature is thus reached again as quickly as possible. Finally, d will also become active if the other lamp has burned out, which one notices immediately when the door is opened, as only one lamp then ignites. Lamp E will, of course, ceteris paribus, always burn out first

I use a double-walled wooden box with a double door as the thermostat chamber. The incandescent lamps are mounted in a double-walled or at least tin-lined wooden chimney (R, R) of the shape shown in the figure, partly to maintain the same temperature everywhere, and partly to keep the light away from the crops. I use 25-candle incandescent lamps at a voltage of 110 volts; stronger lamps easily cause excessive sparking at the contacts. Two such lamps are sufficient for a chamber of more than 100,000 cm. The advantages of this apparatus are:

1. Precise and reliable regulation. An accuracy of 1/10 can be easily achieved.
2. The simplicity with which one can quickly adjust to other temperatures.
3. The speed with which reheating occurs after the door is opened.
4. The safety compared to a day and night

burning open gas flame, especially in laboratories, where the possibility of gas explosions caused by it can hardly be completely ruled out.

5. The price is very low (approx. 1/5) compared to commercially available thermoregulators of equivalent accuracy and safety. 1)

As for operating costs, however, the situation varies somewhat, depending partly on the local price of electricity, and partly and mainly on whether the thermostat is installed in a heated room. In the latter case, one can expect a light bulb to burn for a maximum of about 10 hours out of 24 hours. If the thermostat is only needed from time to time, the operating costs can be even lower than for gas, because one only needs to turn on the power shortly before use, whereas an ordinary thermostat must be lit continuously to be operational

1) Mr. Thomsen, electrician, Sortedamsdosseringen 771, Copenhagen N., supplies the regulator for 20 marks; a complete thermostat with a capacity of approximately 70,000 cm^3 for 100 marks

IV.

Investigations into the bactericidal effect of the various parts of the spectrum by Valdemar Bie.

The investigation of the bactericidal effect of the various spectral regions is not only of great theoretical and practical hygienic interest, but also of utmost importance for the therapeutic application of the bactericidal ability of light. It shows which rays should be excluded as useless or harmful, and which, for the purpose of treating patients, should be exposed to light in the largest possible quantities. By using various light sources and light filters, the composition of the phototherapeutic agent can be mastered to the same degree as the composition of any other therapeutic agent.

Earlier researchers of these relationships did not achieve a reliable result, partly because they did not master the physical part of the experiments and partly because they used relatively weak light. I will

The following describe the nature of the experiments and the results, for comparison with the technique developed here at the Institute.

Literature Review.

Downes and Blunt (1877) and 1878 addressed the present question in the two papers in which they first demonstrated the bactericidal effect of light. They cultivated the bacteria in small test tubes with Pasteur's liquid; usually, they inoculated with a liquid containing numerous bacterial species (not pure cultures); sometimes, self-infection was used.

Some of the test tubes were exposed to sunlight, either in boxes made of colored or clear glass; others were exposed directly to sunlight, and still others were packed in light-tight lead plates.

Whether microorganisms were developing could be determined from the turbidity of the liquid, and whether they were bacteria was confirmed by microscopy

In the first series of experiments, no spectroscopic examination of the colored glasses was carried out; in the other, this examination gave the following result: the blue glasses allowed the violet and blue rays, as well as some green and yellow-green rays, to pass through, while the yellow glasses allowed the entire spectrum to pass through, except for the violet and about half of the blue rays. The red glasses allowed the red and orange rays to pass through.

The test tubes in which bacteria first developed were those packed in lead; these were followed by the

Downes and Blunt: Researches on the Effect of Light upon Bacteria and other Organisms, Proceedings of the Royal Society of London. December 6, 1877, Vol. 26

those in the red box, and shortly afterwards those in the yellow one; no bacteria developed in the test tubes in the blue and the light glass boxes. Downes and Blunt stated the result of the two series of experiments in the following sentences. "As far as our investigation extended, the effect seems to be mainly, yet perhaps not exclusively, connected with the chemical rays of the spectrum." - "That the effect depends mainly on the blue and violet rays is proven by the great difference between the test tubes in the blue and the yellow boxes, the latter allowing all rays to pass through except the violet and a portion of the blue ones." -

Furthermore, the experiment seems to show that the red and orange rays are not entirely ineffective, for the turbidity occurs later in the test tubes in the red box than in those encapsulated in lead, as soon as the nutrient liquid is sufficiently concentrated

If the phenomena were represented in a curve, it would have its peak in or near the violet and quickly decrease into blue or green, but then extend approximately as far as the red is visible.

E. Serrano Fatigati (1879) only reports about his technique that he represented colored light using solutions of fuchsin, nickel nitrate (green), Lyon blue, and Parma violet. He came to the conclusion that violet light favors the development of lower organisms, while green light retards it.

Downes and Blunt: On the Influence of Light upon Protoplasm. Proceedings of the Royal Society of London. December 19, 1878. Vol. 28

E. SERRANO FATIGATI: Influence of various colors on the development and respiration of infusors. Comptes rendus midweekly des séances de l'Académie des sciences, volume 89, 1879, p. 959.

Arloing (1885) conducted some experiments with Bacillus anthracis, cultured in flasks containing uncolored chicken broth. These were placed in a thermostat with a glass door and illuminated by a strong gas lamp, the light from which was collected on the flask by a glass lens. The colored light was produced by passing the light through light filters (glass dishes with parallel, flat walls) containing colored liquids. Control flasks were placed in a dark thermostat at the same temperature

The author summarizes the results of the experiments as follows:

"The presence or absence of artificial white or colored light does not influence the growth of Bacillus anthracis too much; however, spore formation is most rapid in the dark and in the less refractable rays of the spectrum." By this, the author means those flies to the left of the Frauenhofer line, i.e., the red, orange, yellow, and green.

Later, Arloing conducted some experiments on the influence of sunlight on the growth of anthrax spores. He again used flasks of broth inoculated with anthrax spores. The sunlight was directed onto the flasks through a heliostat. The colored light was produced, as before, by light filters containing colored liquids. At night, the flasks were placed on ice, if necessary.

If a light filter was placed in front of the flasks,

M. S. Arloing: Influence of the light on vegetation and the pathogenic bacteria of Bacillus anthracis. Reports of the Académie des sciences. February 9, 1885, tome 100, p. 378.

Arloing: Influence of the sun on the vegetation of the spores of Bacillus anthracis. Reports of the Académie des sciences. August 24, 1885, tome 101, p. 511

which only allowed the red or chemical rays to pass through, the illuminated flasks became clouded almost as strongly and quickly as those in the dark.

A simultaneous investigation of the effect of all colors was achieved by allowing a Pasteur's pipette, prepared as usual, to suspend for 4 hours in all seven divisions of the solar spectrum. The next day, bacteria had developed in all pipettes, while the control pipette, exposed to undivided sunlight at the same time, was sterile.

The author therefore states:

"Consequently, the inhibitory or destructive effect on the developmental capacity of Bacillus anthracis does not seem to depend on individual rays of the spectrum; rather, it is due to the undivided sunlight."

LÜBBERT (1886) worked with gelatin cultures of von Stafyloc. pyog. aur. in test tubes. He divided these into four groups; the first group was placed in a blackened box, the second in a container with double glass walls, between which was a solution of potassium chromate (only allowing non-chemical rays to pass through); the third group was placed in a similar container with copper oxyammonia (only allowing chemical rays to pass through), and the fourth in an empty test tube. All four groups were placed in sunlight near the laboratory window for the same length of time. After 10 days of illumination, no difference could be seen in the appearance of the cultures. After four months of illumination, inoculation was carried out from the test tubes, whereby no difference in energy was

LÜBBERT: The Staphylococcus pyogiosa and the Osteomyelitis Coccus. Würzburg 1886, p. 14. Ref. in RAUM: Biological Significance of Light. Journal of Hygiene. 6th vol., 1889, p. 327.

growth persisted. The author has thus obtained a completely negative result, both with regard to the effect of undivided sunlight and that of colored light.

JANOWSKI (1890) conducted experiments with the typhus bacillus, which was inoculated in test tubes as a streak culture on slanted gelatin or agar. The test tubes were lowered into flasks containing colored liquids, with solutions of fuchsin, Bismarck brown, methylene blue, and gentian violet

spectrum of Bismarck brown consisted of red, The orange, and yellow rays and half of the green. The spectra of the other solutions contained all parts of the solar spectrum, only in different amounts. 1) In addition, two test tubes were placed in flasks containing distilled water, one of which was wrapped light-tight.

The flasks were placed 30 cm from the window in a cold room, with the inoculated surface of the gelatin facing the light. In experiments with diffuse daylight, the author found that the development of the bacteria was much faster and more vigorous in the dark and yellow flasks than in the others; within these two groups, the difference was smaller; growth was better in the dark flask than in the yellow one, and better in the red and blue than in the violet one.

Janowski then conducted experiments with direct sunlight. For this, he used test tubes containing bouillon

JANOWSKI: Centralblatt für Bakteriologie und Parasitenkunde. 8th vol., 1890, p. 167.

1) The spectrum of a non-monochromatic solution is always composed of two or more colors, so that, for example, the spectrum of methylene blue consists of a blue and violet section, which contains a large part of the blue and violet rays emitted by the light source, as well as a faint green and yellow part and a very faint red part

Cultures of the typhus bacillus, otherwise the same procedure as in the previous experiments. In addition to the four colored liquids mentioned previously, a solution of potassium bichromate was used, the spectrum of which included the red, orange, and yellow rays, as well as the beginnings of the green

The test tube standing in the dark and the one standing in the dichromate of potash became cloudy after 8 hours; in the other test tubes, the broth remained clear for the duration of the experiment (5 days). The bacteria thus developed just as well behind the dichromate of potash as in the dark; consequently, the rays absorbed by the dichromate of potash, namely the chemically active rays, are harmful. In another experiment, a test tube containing a typhus broth culture was placed in a flask containing gentian violet. At the same time, one test tube was placed in a flask containing Bismarck brown and another in a flask containing fuchsin. After 2 days, a strong cloudiness developed in the test tubes containing Bismarck brown and the dichromate of potash. Those that had stood in the fuchsin and gentian violet, however, were sterilized during the same period

SANTORI (1890) presented almost monochromatic light through two colored glass plates mounted in a wooden frame 5 cm apart; a test-tube gelatin culture was suspended between the glass plates and exposed to sunlight. The experiment was carried out simultaneously with red, violet, and unstained glass. Cultures of the typhus bacillus, Stafyloc. pyog. aur., and Spirillum cholerae asiaticae were used.

SANTORI: Bulletino della Academia medica di Roma, vol. 16, 1889-90, p. 386

It was shown that undivided sunlight has a powerful microbicidal effect, but that "the violet and red rays of sunlight do not kill the microorganisms, nor do they produce any visible change in their development."

Raspe (1891) found that blue and yellow rays limit the developmental capacity of anthrax spores, while green, violet, and red rays have no discernible effect.

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Geisler (1892) placed some test tubes containing gelatin streak cultures of the typhus bacillus in the infrared, red, yellow-green, violet, and ultraviolet parts of the solar and electric light spectrum. The same was represented by two prisms of flint glass, the type of glass that allows most ultraviolet rays to pass through.

Geisler drew the following conclusion: "All rays of the electric and solar spectrum, except the red ones, inhibit the growth of typhus bacilli; this inhibitory effect is the stronger, the larger the refractive exponent or the smaller the wavelength of the corresponding rays."

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Kotljar (1892) investigated the effect of light on Bacillus pseudoanthracis, Sarcina aurantiaca, Micrococcus prodigiosus, and on a raspberry-red coccus grown on agar and potatoes.

Colored rays were produced by allowing the light to pass through a layer of colored gelatin smeared on the outer surface of the test tubes. Only

Raspe: Influence of sunlight on microbes (Diss.). Schwerin 1891. Ref. in Baumgarten's Jahresbericht, 8th year, 1892, p. 505.

Geisler: Centralblatt für Bakteriologie, 6th year, 11th volume, 1892, p. 161

E. Kotlyar: Wratsch 1892, Nos. 39 and 40, ref. in Centralblatt für Bak-teriologie, 12 vols., 1892, p. 836.

Red and violet light were investigated. The result was that growth was inhibited most by uncolored direct sunlight, less by violet rays, and least by red.

Chmelewsky (1892) investigated pus bacteria using the same method as Geisler. He found that the inhibitory effect of light is not only linked to the actual light rays, but also to chemical and heat rays; the red and infrared rays are the least effective

BUCHNER (1893) made agar plate cultures of Typhus bacilli in dishes to whose bottom a cross or something similar made of light-tight paper was glued; the part of the culture below this served as a control. The dishes were placed, with the bottom facing the light source, in the different parts of a spectrum represented by an electric arc lamp with a parabolic reflector and a quartz prism. Quartz allows the extreme ultraviolet rays to pass through, unlike glass; nevertheless, the author uses glass dishes. The author says of these experiments:

"However, the observations made are too few to draw any reliable conclusions from them. So far, it has only been shown that, contrary to expectations, the development of typhus bacilli in the orange, red, ultra-red, and also ultraviolet ranges remained completely uninhibited, while the brightest part of the spectrum: green, blue, and partly violet, exerted a growth-inhibiting and killing effect on the sown bacteria."

P. Chmelewsky: Wratsch 1892, No. 20, ref. in Centralblatt für Bakteriologie, 12th vol., 1892, p. 174.

Buchner: Archiv für Hygiene, 17th vol., 1893, p. 179.

Ledoud-Lebard (1893) investigated the conditions of the diphtheria bacillus in the following way: He placed smaller test tubes of 5 mm diameter containing a suspension of diphtheria bacilli on the axis of test tubes of 3 cm diameter. The large test tubes were then filled with either water or a saturated solution of potassium dichromate, or with an ammoniacal solution of copper sulfate. He found that "the bactericidal power is almost exclusively linked to the most refractable rays of the solar spectrum. These are just as effective as the collected white light. The least refractable rays have no bactericidal effect, or at most such a weak one that the suspensions affected by these rays behave in the same way as those kept in the dark."

MARSHALL WARD (1893 and 1894) placed an agar plate containing anthrax spores, covered with a zinc plate, in sunlight; a letter was carved into the zinc plate. He thus used the "Buchner method" in reverse. The sun's rays passed partly through colored glass and partly through light filters containing colored liquids.

No bactericidal effect was detected behind the glasses, which only allowed red, orange, and yellow rays to pass through, but cut off the blue and violet rays; the effect was doubtful behind a green glass, which absorbed most of the red, orange, and blue-violet rays, but allowed the yellow, green, and some of the least refractable blue rays to pass through

LEDOUD-LEBARD: Action de la luminère sur le bacille diphtérique. Archives de Médécine expérimentale et d'Anatomie pathologique. Serie I, tome 5, 1893, p. 779.

H. MARSHALL WARD: Proceedings of the Royal Society of London vol. 52, 1893, p. 393 and vol. 53, 1893, p. 23.

On the other hand, a distinct effect was discovered behind all glasses that allowed most or all of the blue and violet rays to pass through, whether or not they blocked the red, orange, and yellow rays. The result was therefore that the bactericidal effect of the sun's rays was due to the rays of the blue-violet half of the spectrum.

This result was essentially confirmed when the light filters were used with ammoniacal copper oxide solution, which blocked all rays from the red to line b (in the green), and with a solution of potassium dichromate, which blocked all rays from b to the right. This experiment showed that the rays passing through potassium dichromate inhibit growth slightly, but much less than the others.

Ward obtained approximately the same result in later investigations with essentially the same arrangement as the one described here, as well as in the following beautiful experiment:

The spectrum of sunlight or electric arc light was projected onto an agar plate into which the spores and bacteria to be examined had recently been inoculated. Bacillus anthracis, Bacillus subtilis, a violet Thames bacillus, and several other Thames bacilli were examined. The spectrum of electric light was displayed through a quartz prism. The agar plate culture was kept on ice throughout the experiment.

Neither in sunlight nor in electric light did the infrared, red, orange, yellow, or green

H. MARSHALL WARD: Proceedings of the Royal Society of London vol. 54, 1894, p. 472.

H. Marshall Ward: Proceedings of the Royal Society of London vol. 56, 1894, p. 315.

rays an effect; this began only at the blue end of the green, reached its maximum at the transition between the blue and violet, and was again restricted in the violet and ultraviolet regions. In electric light, which is very rich in ultraviolet rays, the effect extended far into the ultraviolet as soon as the light passed through quartz; but if a piece of glass was inserted, a large part of these effective rays was cut off

DIEUDONNÉ (1894) prepared agar plates of Microc. prodigiosus and Bacillus fluoresc. putridus in Petri dishes; a paper cross was glued to the bottom of the dishes according to Buchner's method. To visualize the different divisions of the spectrum, he used: 1. an aqueous solution of potassium bicromate, which transmitted the red, yellow, and part of the green rays; 2. a concentrated aqueous solution of copper chloride with the addition of a few drops of hydrochloric acid; it transmitted only the green and green-blue rays; 3. ammoniacal copper sulfate solution, which absorbed red, yellow, and green; 4. 1% quinine sulfate solution with a few drops of sulfuric acid; it absorbed ultraviolet. These solutions were poured onto flat bottles that were placed on the underside of the dishes. The thickness of the absorption layer and the duration of illumination were always the same. Sunlight and electric arc light were used as light sources

Behind the solution of potassium bichromate, growth and pigment formation were just as abundant as in the control plate in the dark; behind the copper chloride solution, a slight inhibition of development was observed, in that pigment formation was weak and slow; behind

DIEUDONNÉ: Works from the Imperial Health Office, 9 B., 1894, p. 405

The copper sulfate solution killed all germs; behind the quinine sulfate solution, there was very minimal growth

In another experiment, Dieudonné placed the dishes in the various sections of a spectrum approximately 2 m wide, represented by an electric arc lamp at 900 standard candles and through a Rutherford prism. In this series of experiments, in addition to Bacillus fluorescens and Microc. prodig., Bacillus coli was also examined. Growth in the ultra-red, red, orange, and yellow parts was very abundant; the pigment formation and trimethylamine development of the first two bacteria repeatedly appeared to be even stronger than on the control plate in the dark. No weakness of growth could be detected between D and E, i.e., in the yellow part of the spectrum; on the other hand, a clear inhibition of development was observed in the green part between E and F, and in the blue, violet, and ultraviolet parts of the spectrum, the plates were completely sterilized

D'ARSONVAL and CHARRIN (1894) illuminated a pyocyaneus culture with bright electric arc light, another with the same light after it had passed through a solution of dichromate of potassium, which robbed it of its chemical rays; then a drop of the culture was inoculated into agar, which was placed in a thermostat. By sufficiently long illumination, the former culture was sterilized, while the latter was not affected.

BILLINGS and PEEKHAM (1895), who worked with typhus and colibacillus, found no particular effect of the

D'ARSONVAL and CHARRIN: Archives de physiologie normale et pathologique 5th series, volume 6, 1894, p. 335.

BILLINGS and PEEKHAM: Science, February 1895, p. 169, ref. in Centralblatt für Bakteriologie. 19th vol., 1896, p. 244.

sunlight passed through red, orange, yellow, or green glass panes (not spectroscopically examined); in contrast, the blue and violet rays killed the bacteria almost as quickly as undivided sunlight.

KRUSE (1895) dried anthrax spores on coverslips, placed these in dishes, and illuminated them with sunlight. From time to time, a coverslip was removed from each dish; the dried spore layer was softened with a little broth and then processed for plate culture. The experiment was carried out on May 3, 1892, in Naples

The remaining ratios can be learned from the following diagram, in which the numbers indicate the number of spores capable of growing.

The duration of illumination	No. 1 freely illuminated	No. 2 illuminated behind 2-3 cm of water	No. 3 illuminated behind 2-3 cm of concentrated aluminum solution	No. 4 behind illuminated behind a spectroscopically pure red glass plate	No. 5 illuminated behind a blue glass plate	No. 6 illuminated behind an opaque plate
Before the experiment	∞	—	—	—	—	—
1 hour	∞	∞	∞	∞	∞	∞
2 hours	10 000	11 000	10 000	∞	∞	∞
3 „	64	5 600	4 000	∞	∞	∞
4 „	210	1 160	750	∞	∞	∞
5 „	0	730	132	∞	∞	∞
6.5 „	0	8		∞	∞	∞
10 „	—	—	—	∞	11 000	∞
14 „	—	—	—	∞	6 100	∞
20 „	—	—	—	4 000	0	∞

Later experiments produced a very similar result. The table clearly shows that the rays which

KRUSE: Zeitschrift für Hygiene 19, 1895, p. 322, Chapter 4

pass through the blue glass, have a more powerful effect than the red ones. However, the difference does not seem to me to be so great as to allow the author to conclude that, of the rays of the spectrum, the most refractable ones are primarily responsible for the antiseptic effect of light, because an effect of light lasting 15-16 hours, which has passed through the blue glass plate, corresponds to an effect of the red rays lasting 20 hours; this is not a great difference.

I will go into Beck and Schultz's work (from November 1896) in more detail, as it is the latest in this field and provides a good example of how such experiments should not be carried out. Nevertheless, the authors declare all previous experiments invalid because they were not carried out with a monochromatic light

For their experiments, Beck and Schultz mostly used pigment-forming bacteria grown as streak cultures on agar in test tubes. These were placed in boxes whose only opening was closed with light filters. The liquids used were those specified by Landolt, which produce monochromatic light as far as possible, i.e., light consisting of rays that lie very close to one another in the spectrum. The use of such liquids would be highly recommendable if the rest of the experiments were arranged accordingly. The more monochromatic the light becomes, the more rays are cut off, in other words, the lower its intensity; this can only be remedied by amplifying the light source; but Beck and Schultz only used unconcentrated light: diffuse daylight, direct

Beck and Schultz: On the effect of so-called monochromatic light on bacterial development. Journal of Hygiene, 23 vols., 1896, p. 490

Sunlight and Auer's gas-incandescent light, which was also greatly weakened by absorption and reflection, as the light passed through two or three light filters in succession. Diffuse daylight has only a slight bactericidal effect; if you remove so much of this light through light filters that only a small fraction remains, you naturally have no reason to expect that this residue could harm the bacteria

Shouldn't direct sunlight be so strong that even a small part of it could weaken the growth of bacteria? One can only judge this if one knows the strength of the sunlight used, but it has not been measured; the authors only say that the experiments were carried out in spring and summer. Yet even if the very strongest direct sunlight were used, there is one circumstance that greatly limits the prospect of its strong effect. Admittedly, the boxes with the cultures were placed at a south-facing window (which was often closed), but the authors do not say that they were on a heliostat or at least turned toward the sun. Therefore, it is possible that the test tubes were illuminated for only a very few hours a day, and probable that they were not positioned at right angles to the light rays.

The entire technique is such that one could not expect any harmful effect on the bacteria in advance.

The results of the experiments are quite unclear; I will cite one example here

Experiments with Micrococcus prodigiosus.

1. In test tubes, 3.5 days, plenty of sunshine.

Formation of the pigment + +

Dark. Red . . . . . .

light. . . . . —

	light	
yellow +	„	—
green	„	—
sunlight		almost uncolored.

2nd plate culture, 3 days, plenty of sunshine.

	Formation of the pigment
Dark	+
blue light	±
green „	±
yellow + „	—
red „	—
sunlight	colorless

The colors are arranged according to their effect; + denotes "no or the slightest influence on pigment production, thus the best-developed colony." + denotes a stronger and the strongest effect of light. One gets an idea of the author's lack of logic when one compares the sentence in quotation marks with the following quote: "When judging the influence of light on bacteria, one must not identify pigment production with growth." "Rather, the development of such bacteria and their pigment formation are two different things." This remark is undoubtedly very correct; nevertheless, in their description of these experiments on the development of the bacteria, the authors only mention pigment formation and say nothing at all about the nature of the growth.

The authors' summary of the paper is the following: "As our experiments show, no colored light has a development-inhibiting or killing effect on any of the bacterial species examined."

For the sake of clarity, I have presented the results of the previous investigations in a diagram; + denotes bactericidal effect, no effect, o means that the type of radiation in question was not investigated.

	Ultraviolet	Violet	Blue	Green	Yellow	Orange	Red
Downes and Blunt 1877	1	+	+	+	+	+	+
Fatigati 1879	1	±	o	+	o	o	o
Arloing 1885	1	±	±	±	±	±	±
Lübbert 1886	1	±	±	±	±	±	±
Janowski 1890	1	+	+	+	±	±	±
Santori 1890	1	±	o	o	o	o	±
Raspe 1891	1	±	+	±	+	o	±
Geisler 1892	1	+	+	+	+	+	±
Kotlyar 1892	1	+	o	o	o	o	+
Chmelewsky 1892	1	+	+	+	+	+	+
Buchner 1893	1	+	+	+	o	±	±
Ledoud-Lebard 1893	1	+	+	±	±	±	±
Marshall Ward 1893	1	+	+	±	±	±	±
Dieudonné 1894	1	±	+	±	±	±	±
d'Arsonval and Charrin 1894	1	+	+	±	±	±	±
Billings and Peekham 1895	1	+	+	±	±	±	±
Kruse 1895	1	+	+	o	o	o	+
Beck and Schultz 1896	1	±	±	±	±	±	±

Critique of the earlier investigations

The earlier investigators used, on average, rather weak light sources. It is obvious that if one divides the light and lets each part act independently, one must amplify the light source to obtain the same effect in the same time. This seems to be the earlier

not to have appreciated the value of the researcher. Arloing, however, concentrated the light through a glass lens into parallel rays, as far as I can understand. However, his light source was nothing other than a strong gas flame, i.e., such a weak light that one must, at least now, consider it improbable from the outset that it should have — any discernible effect on bacteria if part of it was removed by colored liquids

Other investigators used diffuse daylight and Auer's gas-incandescent light; these, too, are too weak. The only sufficiently strong light sources are sunlight and powerful electric arc lamps. Sunlight is indeed the strongest light source, but, at least in our climate, it is too variable to be used for a long comparative series of experiments. Electric arc lamps have been used by some authors, but only Geissler and Dieudonné have given the luminous intensity (respectively 1000 and 900 standard lights); this is too weak light

The authors' lack of concern for the physical side of the task is also evident in the fact that almost none of them measured the chemical action of their light source, or, if they used artificial light, stated its intensity and the distance of the culture from it; they only stated that they used, for example, direct sunlight; but its chemical power naturally varies greatly according to the latitude, the month, and the time of day when the experiment was carried out. Anyone investigating the bactericidal power of heat will certainly measure the temperature; in corresponding investigations of light, measuring its intensity has not yet been considered necessary; but it seems to me equally necessary in both cases to make as accurate a measurement as possible.

Measuring the light is especially necessary when one cannot demonstrate a bactericidal effect of all the components of the light. In this case, one cannot conclude, as all authors do, that the components that give no reaction do not actually have a bactericidal effect; one can only conclude that these components have no effect in the light of the applied intensity; in stronger light, they may perhaps have a significant bactericidal ability. Only when the light intensity has been measured can one judge whether the result of the experiment is reliable

Besides strong lighting, there is another key requirement for obtaining an accurate result: that the light has the best possible conditions to penetrate even the deepest layers of the bacteria's food substrate. This requirement was particularly not met by the older investigators. Arloing, for example, needed a broth culture in glass flasks; some of the other investigators used cultures in test tubes. Regarding these, as well as the flasks, when using flowing food substrate or stab culture, a large portion of the chemical rays is lost upon absorption in the food substrate, and this acts like a converging lens, so that only a wedge-shaped portion of the culture, located in the center of the glass, is illuminated

The deficiencies highlighted make it understandable why no fewer than three of the earlier investigators found no effect at all from colored light, and why so few noticed an effect from weakly refractable rays; for, if one organizes the experiment in such a way that the sum of all components of the light either does not harm the bacteria at all or only to a slight degree, it is naturally even less possible to demonstrate a bactericidal ability in the individual qualities of the rays

assign, especially to the less powerful ones, even if they actually have the same effect. The only way to obtain an accurate result is to apply such strong light and allow it to act on the bacteria under such favorable conditions that even the least effective rays can produce a distinct reaction.

Own experiments

I already carried out the present experiments in the spring of 1897. Due to the rapid development of the technical resources of Finsen's Medical Light Institute, it is quite inevitable that they now appear somewhat outdated. Nevertheless, I have decided to present them in a foreign language because, despite their shortcomings, which I myself fully recognize, they seem to me to represent an advance compared to earlier work in this field. It seems to me that I have demonstrated more precisely to which spectral regions the bactericidal effect of light is essentially tied than previous investigators have done, and in addition, I have made a first attempt to make this relationship the subject of a quantitative investigation by demonstrating how great the difference is between the effects of the various spectral regions

The numerical values I found cannot claim to be considered exact. The accuracy of such an investigation suffers from the lack of reliable tools for comparing the luminous intensity in the different parts of the spectrum.

With the physical collaborator of the Light Institute, Mr. Candidate Mag. Absalon Larsen, I attempted to make a measurement using Vierordt's and Glahn's spectrophotometers. However, since neither of them gave usable results in the blue and violet ranges, and they obviously cannot measure ultraviolet at all—precisely the regions that are important—I had to refrain from making such a determination

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I worked with Bacillus prodigiosus in this series of experiments. I chose it because we always use it at the "Light Institute" (see Finsen's book "On the Application of Concentrated Chemical Light Rays in Medicine," Leipzig 1899, p. 21, etc.), and because it has often been compared with other bacteria both here and elsewhere without any significant difference being discovered, so that its reaction can be considered typical. As the light source, I used an electric arc lamp of 35 amps, 46-44 volts, approximately 6000 standard candles. To ensure the adjustment of the current intensity as accurately as possible, the automatic regulation mechanism is supported by an adjustable rheostat

I concentrated the light using an apparatus roughly like the one described in Finsen's above-mentioned book, p. 20. It consists of glass lenses mounted in a brass tube; in one end of the apparatus are three plano-convex glass lenses; the one nearest the light has a diameter of 163/4 cm; all together act like a single lens with a focal length of 15 cm

further. The apparatus is suspended in such a way that its axis forms an angle of 45° with the direction of the carbons, and that the positive carbon tip is exactly 15 cm from the nearest lens. The three matching lenses will then collect all rays emanating from the lamp that strike them into parallel rays. These continue through the brass tube and, at the other end, strike a duckweed (a layer of water enclosed on the sides of the brass tube, at the ends of two large watch glasses). The thickness of the water layer is 17 cm at the edge of the lens; this duckweed collects the parallel rays into convergent ones. As the light passes through the water layer, it is cooled by the water absorbing one of its warmest components, namely the ultra-red rays. This ensures that the bacteria are not so easily killed by the heat

Since there is no actinometer that can measure concentrated light, I had to take a detour when measuring the light intensity. I cut strips from a piece of photographic paper (Aristo paper) and illuminated them partly with concentrated light at a location where the cultures were placed, and partly with unconcentrated light at a certain distance (18 cm) from the carbon tips, and at such a height that the paper was struck by the strongest light rays, those that make an angle of approximately 45° with the horizon. The paper was held behind a photographic instantaneous shutter. The difference in chemical action was demonstrated by testing how many times I should let the instantaneous shutter act to obtain the same blackening of the paper with unconcentrated light as that which appeared when I

opened it twice in the concentrated light. Once I had demonstrated this relationship, I only needed to measure the unconcentrated light at the same point as before with Vogel's photometer to be able to specify the intensity of the concentrated light in one of the commonly used actinometric measures.

If I say that I measured the intensity of the concentrated light, this is not strictly correct; one cannot do so at all, since the marginal rays have a far weaker chemical effect than the rays in the center of the light cones. My measurement applies only to the center of the light cones. The illumination time was so short that these rays just produced a noticeable blackening of the paper when the instantaneous shutter was opened twice; the marginal rays made no impression at all

The small blackened spot produced by the concentrated light was cut out; similarly, pieces of the same size were cut out from the pieces of paper that had been exposed to the unconcentrated light at different times; they were then compared in a dark room under incandescent lamp lighting. The pieces of paper were observed through smoke-tinted glasses to correct any slight color difference. A difference of approximately 1/7 of a second in unconcentrated light was clearly visible.

It was shown that the paper had to be illuminated for twice as long in unconcentrated light as in concentrated light to obtain the same degree of blackening; since the effect on the paper is proportional to the illumination time, the chemical effect is consequently 1:10.

On the paper in Vogel's photometer, No. 12 could be clearly distinguished, and No. 13 and No. 14 could just be seen; I refer to this effect as No. 14

(27.88 light units). I exposed for 1 minute and used filter paper dipped in a 4% solution of potassium dichromate; the paper was freshly prepared.

The intensity of the concentrated light at the location where the cultures were applied therefore corresponds to 10 × 27.88 = 279 Vogel light units. Because of the many sources of error, this result can, of course, make no claim to accuracy. For comparison, I mention that the highest sunlight intensity I found in the summer of 1898 was 57 units for an exposure of 1 minute

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I used agar as the food substrate for the bacteria. The illuminated cultures were plate cultures, prepared in the usual way at 45°C in square flasks. Each flask contained 2 cm^3 of agar, and two vials of prodigiosus broth culture were sown into it. The area over which the agar was distributed was 7134 cm^3; the thickness of the agar layer was approximately 0.5 mm over most of the area; at the edge, where the adhesive force acts, approximately 2 mm.

As soon as the agar had become stiff, the flasks were placed on ice. Since Bacillus prodigiosus can grow a little under these conditions, I left the flasks lying for only a limited time before beginning the experiment—a maximum of 3 days in winter and 12 hours in summer

Before the experiment, I painted a number on the bottle with asphalt paint, indicating the duration of the experiment; finally, I slid a metal case with a round hole of

a couple of centimeters in diameter over the bottle, so that the number was in the middle of the hole. The bottle was placed in a rack so that it was perpendicular to the axis of the light cones, within the focal point at the point where the light cones had a diameter of 2.5 cm. To prevent the bottle from heating up, it was sprinkled with cold water through an irrigator throughout the experiment

When the experiment was finished, for short experiments, the time was measured with a chronograph showing 1/5 of a room — second. The bottle was placed in a dark room at temperature. If the culture had grown, and if it had been illuminated long enough, strong growth was found at the point where the number and the metal case had covered it, whereas weak growth or possibly no growth at all was found in the illuminated part of the culture, i.e., the part that corresponded to the hole in the case and was not covered by the number. This difference in growth caused the number to stand out clearly, so that it could be seen with the naked eye

This method, in addition to the clarity of the reaction, has the advantage of protecting against the two most important sources of error: poor preparation of the culture and excessive heating during illumination. The former error is recognized by the poor growth in the part of the culture protected by the metal case; the latter by the fact that the bacteria are killed in numbers; excessive heating during the experiment is prevented by sprinkling cold water over them.

The experimental order used has several advantages over those of earlier investigators: the light is constant and contains rays with a shorter wavelength than any Finsen Medical Light Institute. 5

other artificial light that could be considered (Auer's gas-incandescent light, for example), and is sufficiently strong that even the influence of the weakest rays can be detected; the disturbing effect of heat rays is excluded; each surface unit of the culture is always exposed to a certain number of light units; the preparation of the culture ensures a constant resistance in the bacteria; the thickness of the agar layer, which is always the same, is so small (approx. 1/2 mm) that its absorption plays almost no role; the detection of even the weakest reaction is very easy.

I produced the various parts of the spectrum by placing a 3 cm wide light filter (a vessel with parallel, flat glass walls) filled with various liquids between the concentration apparatus and the bacterial culture

I carried out two series of determinations: 1. how much time the different spectral divisions need to kill the bacteria, 2. how much time they need to produce the weakest detectable reaction, i.e., to weaken the illuminated part of the culture around the number so much that it grows more slowly than the unilluminated part below the number. The number then just becomes visible on the culture, due to the difference in growth. If the illumination lasted so short a time that the difference in growth is only very slight, this gradually disappears, so that the number becomes invisible. Therefore, I read several times how the culture gradually grew.

I only carried out these two series of determinations when the light filter was filled with distilled water and thus allowed the qualities of rays to pass

which had actually passed through the concentration apparatus. 1)

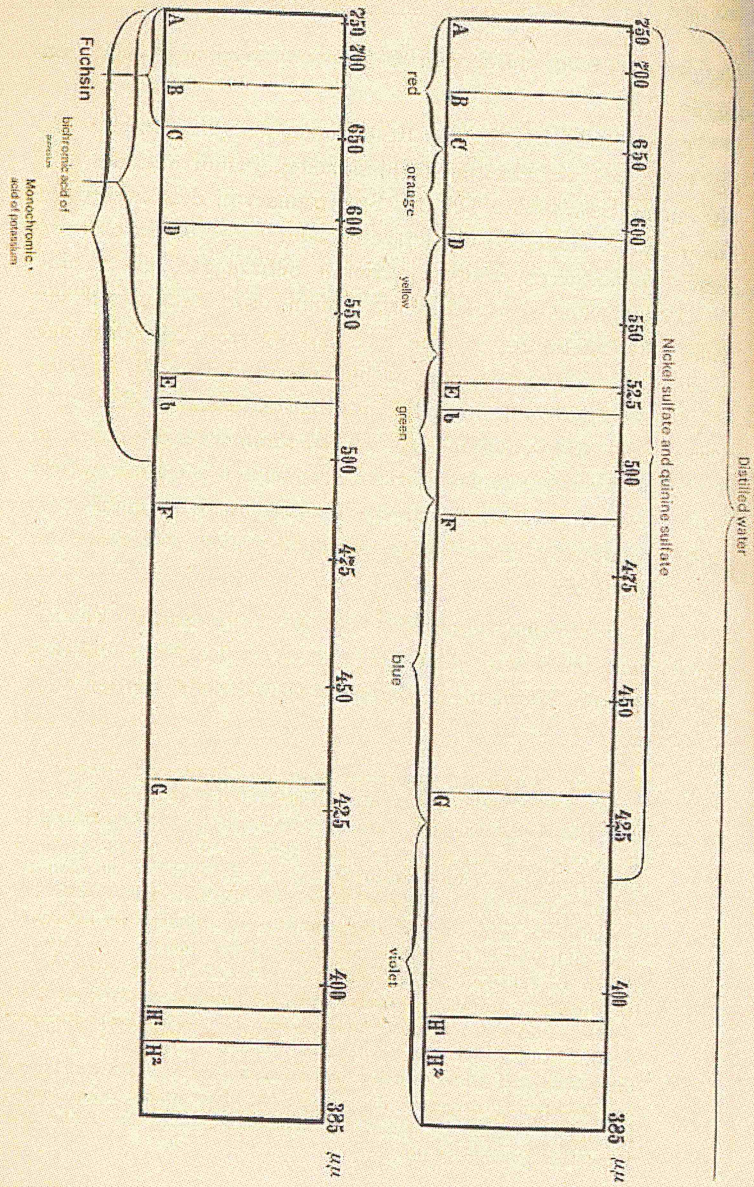
I then carried out the same determination when the filter was filled with different liquids, each of which allowed only a specific part of the spectrum to pass a shorter or longer distance from the extreme left end to the right. For this purpose, I used 1. a solution of quinine sulphate with the addition of a little 1% sulfuric acid, 3. a 112% solution of monochromatic acid of potassium, 4. a 1.5% solution of bichromatic acid of potassium, and 5. a 1.7% aqueous solution of fuchsin. I always used a fresh quinine solution, since the strong light quickly turns the solution yellow, probably due to the conversion of the quinine to yellow quinidine. However, the solution did not turn yellow during the experiment.

The electric arc light and the liquids used were spectroscopically examined with Vierordt's spectrophotometer with the assistance of Dr. Absalon Larsen

1) It could miraculously happen that the reaction time I found is not the same as Finsen's (see Finsen: On the Application of Concentrated Chemical Light Rays in Medicine, p. 26); however, one must remember that it is a matter of opinion whether a number is clear and whether the bacteria around it are killed. While Finsen only called the bacteria weakened when the number was very clear, I used as a criterion a number that could only just be seen; and while Finsen called the bacteria killed when almost all were killed, I required that they should be killed up to the edge of the illuminated area and not be allowed to grow out over the course of about a week. The consequence of this is that Finsen's reaction time for weakening the bacteria is higher and his reaction time for killing the bacteria is lower than mine. No one is making a mistake here; it only matters that the reading is the same throughout a series of experiments.

A drawing of the spectroscopic conditions can be found on page 68. I must note that, just as it is to a certain extent a matter of opinion what name one wants to give a color, the boundaries between the colors of the spectrum are far from being as sharp as in the drawing; in particular, the transition between blue and violet is quite indefinite. Therefore, it is quite arbitrary where one draws these boundaries; I have drawn them according to Müller-Pouillet's textbook of physics.

Since neither concentrated light nor direct electric light can be spectroscoped, I converted this into diffuse light by letting it fall onto a frosted glass screen, which was placed 50 cm from the lamp used for the experiments, at right angles to the strongest light rays. If Vierordt's spectrophotometer is turned toward the illuminated part of this screen, it can be seen that the outermost visible red rays have a wavelength of approximately 760 μμ (millionths of a millimeter); from here, the spectrum continues without interruption by the visible rays up to the rays with a wavelength of 434 μμ at the transition between blue and violet; from 434 μμ to 426 μμ, the spectrum is more faint; the rays with a wavelength of 426 μμ to 418 μμ, on the other hand, form a very intense band From here, the spectrum is again faint up to a wavelength of 395 μμ; from 395 μμ to 388 μμ it is dark, and finally ends with a bright band from 388 μμ to 385 μμ; this band, however, is so faint that it is just visible. Whether the light that has passed through the concentrating apparatus contains rays with a wavelength even shorter than 385 μμ, I have not been able to prove with the available resources, but it can be considered likely because electric arc light contains such rays, and because glass, according to Müller-



Pouillet's Textbook of Physics, allows rays up to 350-300 μμ wavelength to pass through.

The different wavelengths were found by examining the position of Frauenhofer's lines in relation to the scale of the spectroscope.

The placement of a light filter containing water in front of the slit does not change the relative spectroscopic conditions to any noticeable degree. The absorption ratios of the liquids used can be seen from the attached diagram; only I must note that there is a difference between the spectrum of quinine sulfate and that of nickel sulfate: while quinine sulfate only slightly attenuates the bright band lying between 426 μμ and 418 μμ, nickel sulfate attenuates it very strongly; this difference in the spectra is not visible in the diagram, which does not give the quantitative ratios

Considering the usual conditions of the absorption spectra, one can assume that substances that absorb violet rays also do not allow ultraviolet rays to pass through.

In order to find the time required for the rays passing through the liquid in question to kill the bacteria and weaken their growth, I first investigated the effect of two illumination times chosen at random and gradually narrowed the interval between them until I found the desired reaction time. I checked this again by illuminating a culture several times at the time found and at a slightly shorter time.

In the following overview, I have presented the figures found in this way together with the spectroscopic conditions.

Because of the long duration of such an experiment, I did not investigate how much time the red light needed to

To kill bacteria. The light passing through potassium bichromate kills the bacteria completely after 10 hours of illumination, but barely after 8 hours. In order not to make another long experiment, I set the time at approximately 9 hours. All other times have been checked by several experiments within the specified time and within a slightly shorter time.

By examining the diagram on page 72 and the drawing of the spectrum on page 68, one sees the following:

All the individual divisions of the spectrum, excluding the ultra-red, which I left out of consideration, have a harmful influence on the bacteria, but to varying degrees. The effect seems to increase fairly uniformly from the red to the ultraviolet end of the spectrum. Where the maximum effect lies cannot be seen from these investigations

The boundary between the chemically active parts of the spectrum (blue, violet, and ultraviolet rays) and the non-chemically active parts (red, orange, yellow, and green rays) corresponds approximately to the right boundary of the absorption spectrum of monochromatic potassium hydroxide. By comparing the effect of the light that has passed through the monochromatic potassium hydroxide (field IV) and the effect of all components (field I) of the spectrum, one determines the main point: how much of the bactericidal effect is due to the chemical rays and how much to the non-chemical ones. The non-chemical rays produce a significant weakening of bacterial growth during an exposure of 6 minutes; the entire spectrum causes the same effect for 1/4 minute, thus acting 24 times as powerfully. If the effect of the non-chemical rays, i.e., the red, orange, yellow, and green, is set at 1, the effect of the entire spectrum is 24, hence that of the

Table I.

	a The name of the liquid	b The extension of the spectrum in wavelength	c The color content of the spectrum	d The growth is inhibited by exposure to	e The bacteria are killed by exposure to
I	Distilled water	The entire spectrum to the right of 760 μμ	All components of the spectrum	1/4 minute	35 minutes
II	1/2% solution of quinine sulfate	760 μμ-418	Red, orange, yellow, green, blue, and a little violet. The band 426-418 μμ strong	3/4 minute	80 minutes
III	5% solution of nickel sulfate	760 μμ-418	Red, orange, yellow, green, blue, and a little violet. The band 426-418 μμ is weak.	3 minutes	2 hours
IV	1.5% solution of monochromatic acid of potash	760 μμ-4991	Red, orange, yellow, and almost all green	6 minutes	4 hours
V	1.5% solution of bichromatic acid of potash	760 μμ-541	Red, orange, and almost all yellow	18 minutes	about 9 hours
VI	17% solution of fuchsin	760 μμ-656	Red	90 minutes	not determined

chemical rays, i.e., the blue, violet, and ultraviolet 23. Both groups of light rays, both the

Both chemical and non-chemical rays (not counting the ultra-red rays excluded by the concentration apparatus) inhibit the growth of bacteria, but to very different degrees, with only about 4% of the inhibitory effect being attributed to non-chemical rays, while about 96% is attributed to chemical ones. As already stated above, these figures should not be considered exact; in any case, one can conclude that the vast majority of the effect is due to blue, violet, and ultraviolet rays

As can be seen from the overview table on page 57, it has so far been very doubtful whether red, orange, yellow, and green light rays are harmful to bacteria at all. My experiments show that this is indeed the case. The fact that earlier researchers could not reach definitive results regarding the effect of these spectral components is not surprising when one considers that, despite using extraordinarily strong light, I had to expose the bacteria to these types of rays for a long time to achieve any discernible effect. Pure red light only produced the weakest discernible delay in growth after 1.5 hours of illumination. Considering that this reaction was achieved by illuminating all components of the spectrum for 1.5 minutes, 1.5 hours must be regarded as a particularly prolonged illumination

The light that has passed through the quinine sulphate solution inhibits the growth of bacteria after 3/4 minutes of exposure; that which has passed through the nickel sulphate solution only inhibits growth after 3 minutes of exposure. These two types of light cover the same spectral range, 760-418 μμ, and there is no

other clear difference between their spectroscopic relationships than that the previously mentioned band between 426 and 418 μμ in the spectrum of quinine sulfate is intense and faint in that of nickel sulfate. The great difference in effect is undoubtedly largely due to the different luminous intensity of this band. This relationship is a striking example of the importance of light, whose bactericidal power is used therapeutically, being as intense as possible in its blue-violet-ultraviolet part

Outside the aforementioned band from 426 to 418 μμ, the spectrum is faint from 418 to 395 μμ and dark from 395 to 388 μμ; between 388 and 385 μμ lies a faint band, which is the outermost visible part. Finally, outside of this band, there are the invisible ultraviolet rays, which probably extend quite a bit further, up to 350-300 μμ, but whose extent and numerical ratio I have not been able to determine

The effect of these two faint bands, as well as the (unmeasured) ultraviolet rays, is discovered by comparing the effect of light that has passed through distilled water with the effect of light that has passed through quinine sulfate. Part of the difference may be due to the admittedly insignificant weakening of the band lying between 426 and 418 μμ upon passage through the quinine sulfate solution.

Despite the faintness of the light and the small extent of the two outermost bands and the strong absorption of ultraviolet rays by the glass, this outermost part of the spectrum has a powerful inhibitory influence on the growth of bacteria. How much of the effect is due to the two violet bands mentioned and how much to the ultraviolet rays cannot be determined.

without knowing the extent and ratio of these rays, or one would have to be able to use a substance as a light filter that would destroy them without taking some of the visible rays with it. However, to my knowledge, such a substance does not exist

Incidentally, I would like to point out that the range of ultraviolet rays cannot be precisely defined; there are individual differences in the ability of the eyes to perceive the extreme violet rays, and the ability of these rays to make an impression on vision varies depending on the type of light source, since this, like any other light impression, depends on the quantitative ratio of the rays. Sunlight, for example, can only be seen in the spectroscope I use up to Frauenhofer's line H_2 (393 μμ); at approximately the same point, the dark band in the spectrum of electric arc light begins; the bright band, which extends further out, between 388 and 385 μμ, thus corresponds in wavelength to the invisible ultraviolet rays in sunlight. The fact that these rays are only visible in the spectrum of electric light is due to

1) Widmark has demonstrated that the limit for the outermost visible violet in electric arc light shows the following significant individual oscillations, but does not vary significantly according to age groups under 50-55 years:

Maxim. Minim. At

ages 11-20 years: 378-395 μμ on average 386 μμ " 21-30 31-40

" " 371-395 " 380.5-394.5; 382.5" " — gränsen

" 13 382.91 388.7 " " — för det

" " 372.5-393 11 — WIDMARK: Om — synliga

spektrum. [On the limit for the visible spectrum]. Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar 12. Maj 1897, No. 5, p. 287.)

It is in good agreement with these studies that Candidate Larsen and I, both of whom are between 21 and 30 years old, could see down to approximately 385 μμ. Neither of us was familiar with Widmark's studies at the time

probably because more rays are concentrated at this point in electric light than in sunlight.

When assessing the effect of ultraviolet rays, one must also take into account that the light has passed through thick layers of glass, which absorbs all rays with a wavelength shorter than 350-300 μμ that may be present in the arc light. However, one is able to investigate the effect of concentrated light, which contains rays of even shorter wavelength, by collecting the light with rock crystal lenses instead of glass; because rock crystal allows rays with a wavelength of up to 200 μμ to pass through. However, the institute did not yet have collecting apparatus with rock crystal lenses when these experiments were carried out, and so I had to postpone an exact determination of the effect of this spectral region until another opportunity

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So far, I have calculated exclusively based on the time it takes for the light to weaken the growth of the bacteria. From Table 1, it is easy to see that the relationship between the effect of the various sections of the spectrum changes somewhat when calculated based on the time it takes for the light to kill the bacteria, although the main thing: the predominant influence of the blue, violet, and ultraviolet rays remains unchanged. I cannot say why this is the case; there are several possibilities that cannot be overlooked on the basis of the present investigations. 1)

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1) It is certainly largely due to the different bactericidal powers of the marginal rays and the central rays of the light cone, as I was able to detect the slightest weakening of the bacteria when the number appeared in the center of the illuminated spot; in contrast, I only considered the bacteria to be killed if they were also killed at the edge of the illuminated part. (Compare p. 63).

The entire relationship to the bactericidal effect is easily understood from the considerations presented above.

Summary.

1. All rays of the spectrum, except the ultra-red, which have not been investigated, from the red upwards, inhibit the development of bacteria. Whether the red rays are capable of killing bacteria has not been directly proven; all the other parts of the spectrum have the ability to do so.

2. The effect increases with the refractive index.

3. The effect is mainly due to the blue, violet, and ultraviolet rays.

4. These results apply to Bacillus prodigiosus and to the specific light I used (the light of an electric arc lamp of 35 amps and 46-44 volts, concentrated by the Finsen light-collecting apparatus described).

V.

On the Power of Light to Kill Shoot and Mold Fungi

by

Valdemar Bie.

Knowledge of the effect of light on shoot and mold fungi has been very limited until very recently; it was usually assumed that it had the same effect on these organisms as on other plants. I will give some results of earlier investigations below.

De Bary (1863) discovered no effect of light on the growth of Peronospora species; on the other hand, he found a favorable effect on the development of Uromyces appendiculatus. When he sowed his spores on bean leaves that were illuminated from only one side, they grew first on the illuminated side.

Van Tieghem (1881) demonstrated the same thing with Penicillium glaucum; in a bottle with spore-containing oil,

DE BARY: Research on the development of some parasitic mushrooms. Annales des sciences naturelles, p. IV, Botanique, vol. 20, 1863, pp. 54 and 98.

VAN TIEGHEM: Action of light on the vegetation of Penicillium glaucum in oil. Bulletin of the French Botanical Society, 1881, p. 186.

This fungus in such a way that its contour formed a regular curve, the apex of which corresponded to the middle of the side of the bottle facing the light; on the opposite side, the mycelium did not develop at all or almost not at all. If porous, moist, burnt clay was placed in a bottle containing spore-containing oil, the fungus also grew only on the sides of the clay facing the light.

Van Tieghem (1884) and Winter (1874) are even of the opinion that light is necessary for the development of the mycelium of Pyronema confluens and Peziza Fuckeliana de By.

Kny (1884) discovered no influence of light on the rate of reproduction in Saccharomyces cerevisiae.

None of these authors has proven that light is capable of killing budding and mold fungi

Zopf was therefore quite right to note the following in 1890: "Direct sunlight appears to have a slightly fatal effect on the thallus of most saprophytic molds and basidiomycetes, evidently due to the rapid drying it causes. Whether sunlight itself can also have a fatal effect, similar to that of certain schizophytes, remains to be investigated."

Zopf seems to have overlooked one study here, namely that of Downes and Blunt from 1878 and 1879.

Van Tieghem: Culture et développement du Pyronema confluens. Bulletin de la Société botanique de France 1884 p. 356

WINTER: Heliotropism in Peziza Fuckeliana de By. Bot. Zeitung 1874 p. 5. Ref., after F. Elfving: Studies on the Effect of Light on Fungi. Helsingfors 1890 p. 13.

KNY: The Relationship of Light to Cell Division in Saccharomyces cerevisiae. Berichte d. deutschen botan. Gesellsch. II 1884 p. 129. Ref. after Elfving 1 c. p. 15.

ZOPF: The Fungi in Morphological, Physiological, Biological, and Systematic Relationships. Breslau 1890 p. 219. Ref. after Elfving.

DOWNES and BLUNT: Researches on the Effect of Light upon Bacteria

These authors, the originators of the theory of the ability of light to kill microorganisms, have subjected all related questions to excellent, thorough investigation. They made the observation that when unboiled pasteurizer liquid was illuminated, fungi never grew in it during this procedure, even when placed in the dark after a longer illumination; but if the liquid was placed in the dark or in diffused daylight after a shorter illumination period, fungi grew in several cases, but no bacteria.

From this, Downes and Blunt conclude that light delays or even prevents the development of those microscopic fungi that are involved in putrefaction and decay, but that it has a lesser effect on these organisms than on bacteria.

In recent years, numerous investigations have been carried out, but they have not produced any reliable results

Gaillard investigated Oidium albicans and red yeast (levure rouge) by sowing them in flasks of broth and placing the flasks in sunlight during the day and in an icebox at night.

Oidium was not affected by this; individual cultures even grew during the illumination. On solid food substrates, no clear difference could be detected, regardless of whether the culture was in a light or a dark place.

The red yeast also grew during the illumination;

and other Organisms. Proceedings of the Royal Society of London vol. 26, 1878 p. 488.

Downes and Blunt: On the Influence of Light upon Protoplasm. Proceedings of the Royal Society of London v. 28, 1879 p. 199

G. Gaillard: On the influence of light on microorganisms. Thesis. Lyon 1888.

One of the cultures even seemed to have grown much more than those that had been kept in a dark thermostat for control.

On solid food substrates, colonies always appeared clearer and thicker in direct or diffuse sunlight than in the dark.

According to Gaillard's investigations, sunlight therefore favors the development of the two species mentioned

Laurent exposed spores of Ustilago carbo in glass flasks to direct sunlight. After 8 hours of illumination in July, the spores had died, while those serving as a control developed normally. These spores were far more easily influenced than the spores of Aspergillus niger and glaucus, Botrytis cinerea, and Cladosporium herbarum. Spores of Penicillium and Cladosporium were also killed by the light, the former more easily than the latter

Elfving discovered that intense summer sunlight prevented the spores of Aspergillus glaucus from germinating, but did not kill them, even after 8 days of exposure. The fungus was easily destroyed by the light after germination in the first stages of development; fully grown mycelium, on the other hand, could be exposed to sunlight for several days without dying. The spores behaved in the same way: those that had just formed were killed by sunlight in one day; the mature ones could be insolated for several weeks without damage.

Martinaud tested the ability of light to sac-

Laurent: Influence of light on the spores of charcoal des cereales. Comptes-rendus Soc. roy. de Botanique de Belgique, vol. 28, 1889, p. 162. Ref. after Elfving, 1 c. p. 19

F. ELFVING: Studies on the Effect of Light on Fungi. Helsinki 1890 p. 105.

MARTINAUD: Influence of solar rays on fungi, which the Finnish

to kill Saccharomyces apiculatus and Saccharomyces ellipsoideus I and II by illuminating either freshly picked grapes immersed in sterile water in which he had suspended shoot cells, or a sterile glass plate or paper treated in the same way. After illumination, an experiment was carried out to see whether the germs grew in sterile wine must.

It was found that the germs were killed at 41-45° C after illumination for 4 hours, and at a lower temperature only after longer illumination.

Marshall Ward used the method described in my previous paper

He demonstrated microbicidal activity on the following species: Oidium lactis, Chalara mycoderma, Saccharomyces pyriformis, and Stysanus. The following species, however, gave a negative result: Aspergillus glaucus, Penicillium crustaceum, Mucor racemosus, Nectria cinnabarina, and Botrytis cinerea.

Marshall Ward points out that all the species that gave a positive result have hyaline, colorless, or very pale yellowish spores, whereas all the species that were not affected have clearly pigmented spores.

I will not go into a detailed criticism of the method of investigation used by the authors cited, since it would essentially be a repetition of what I have already stated in my previous treatise. However, I must contre à la surface des raisins. Comptes rendus de

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l'Académie des sciences t. 113, 1891 p. 782

H. MARSHALL WARD: Further Experiments on the Action of Light on Bacillus anthracis. Proceedings of the Royal Society of London, vol. 53, 1893, p. 23.

Again, point out that the main error in previous experiments of this kind was the use of too weak light and the lack of light measurements

It goes without saying that one must use light of a certain intensity to produce a clear difference between the growth of fungi in the light or in the dark. It is no less necessary to measure the light intensity. One cannot speak of light in general, nor of heat; just as it follows naturally that one measures the temperature in experiments with the bactericidal effect of heat, one must also, of course, state the intensity of light in experiments of the same type with light. If this is not done, it is impossible to assess the value of the experiments later, among other things because it is not certain that the microorganisms react the same to all intensities or types of light.

I emphasize this because I realize that in experiments with the strongest light available to me, the influence of light on the growth conditions of the microorganisms in question was not exhausted; it will undoubtedly also be of interest to test the effect of weaker light

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The procedure in my experiments was essentially the same as that described on pages 60 and 61, except that I took into account a result of my earlier experiments, namely the strong effect of ultraviolet rays. In order to utilize this as much as possible, the concentrating apparatus with glass lenses described on page 61 was replaced by one with rock crystal lenses, which allow far more ultraviolet rays (see page 76) to pass through

and instead of culture flasks, I used dishes made from a rock crystal plate mounted in a brass ring. Incidentally, no essential changes have been made to the construction of the concentration apparatus. It consists, like the one described earlier, of two sets of lenses mounted in a brass tube. Next to the light are two lenses, 6.5 cm in diameter and 30 and 20 cm focal lengths, respectively, mounted at a distance of 12 cm from the lamp, which collect the divergent rays radiating from it into parallel ones. At the opposite end of the brass tube, two lenses are mounted, which collect the parallel light rays into convergent ones and enclose a 30 cm thick layer of distilled water, which cools the light by absorbing the ultra-red rays

The electric lamp burned at 45 amps and 50-45 volts (approximately 10,000 standard lights).

I prepared the cultures by scraping off some of a surface culture, suspending it in wort, filtering it through hygroscopic cotton, and mixing the filtrate with wort agar, which was then evenly distributed in the dishes. However, I could not scrape any of the Aspergillus niger culture and therefore had to make the suspension by shaking the culture with wort, after which I filtered. During illumination, the dishes were placed outside the focal point of the concentrating apparatus at the point where the light cone had a diameter of 4 cm

After the illumination was finished, the dishes were placed in the dark and converted into humid chambers by placing them on moist filter paper with the bottom facing up. I believe I have avoided confusing the effect of light with the effect of heat. I

applied the same precautionary measure as in the previous series of experiments: sprinkling with cold water. Furthermore, I mounted the dish in a clamp without a background; although the light is very warm, under these conditions it passes through the culture without absorbing many heat rays. I have convinced myself through control experiments that a 10% gelatin, whose melting point is approximately 27°C, does not melt by the method used, even when illuminated without sprinkling

reliable investigations by Marshall Ward — The most detailed and been carried out to date, as reported on p. 82, — that have give the result that not all mold and fungal species are killed by direct sunlight. Whether this was due to the light being too weak or to the fact that some species are not actually harmfully affected by the light cannot be judged, especially since the intensity of the sunlight was not measured. In such doubtful cases, the advantage of using concentrated light of such intensity becomes apparent: one can conclude that it is capable of producing a positive reaction in all cases where one can be produced at all. By applying such a light, I have demonstrated that in every case the few species I have examined are inhibited in growth and killed with sufficiently long exposure.

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I have tested 1. Saccharomyces apiculatus, 2. Monilia candida, 3. a red-pigmented Torula species, 4. a Cladosporium species, 1)

1) Prof. Dr. phil. Emil Chr. Hansen, Director of the Physiological Department of the Carlsberg Laboratory, has shown me the kindness to identify this species by microscopic examination

which forms brownish-black pigment, and 5. Aspergillus niger examined.

Regarding these 5 species, my experimental journal contains the following:

1. Saccharomyces apiculatus.

1.3 killed when illuminated for 30 . . . . minutes.
1.9/3 20 " " . . . . "
2.9/3 15 " " . . . . "
1.4/10 " " . . . . "
20/4 5 " " . . . . "
2.2/4 5 " " . . . . "
4 " " . . . not killed.
3 " " . . . . " "
2.3/4 " " . . . . 5 killed.
4 " " . . . . "
2.2/4 5 " . . . . "
. . . . 4.2, " not killed?
" " . . . . 4 not killed.
3 " " . . . . " "

2. Monilia candida.

1.9/3 killed when illuminated for 30 . . . minutes.
2.3/15 " " . . . "
1.4/4 " " . . . 5 almost killed.
10 " " . . . killed.
2.4/20 10 " " . . . "
2.2/4 5 " . . . "
2.3/4 5 " " . . . "
4 " " . . . not completely killed.

3. A Torula species

1/2 illuminated for 30 minutes, ... killed.
" " . . . . 20 not killed.

illuminated for 20 minutes . . . . not killed. 7/3
12/3 30 " " . . . . killed.
25 " " . . . . not killed. 29/3

4. A Cladosporium species.

24/2 illuminated for 30 minutes . . . . killed.
5/3 15 " " . . . . not killed.
7/3 20 " " . . . . " "
10/3 25 " " . . . . " "
12/3 30 " " . . . . killed.

5. Aspergillus niger.

31/ illuminated for 60 minutes, . . . not killed.
20/4 90 " " . . . killed.
29/4 90 " " . . . "
2/5 75 " " . . . not completely killed.
9/5 60 " . . . not killed. "

The fact that a repetition of the experiments always produced the same result, with the exception of two cases (Saccharomyces apiculatus 2.3/4, 4 minutes, and Monilia candida 1.4/4, 5 minutes), seems to me to speak for the accuracy of the test method.

From the experimental journal, one can see that

Saccharomyces apiculatus is killed after 5 minutes, but not after 4 minutes.
Monilia candida 5 and 4 " " " " "
Torula " 30 " " " " 25 "
Cladosporium 30, 25 " " " " " "
Aspergillus niger 90, " " " " "
75.

An illumination time lying between the two times given is the exact expression for the time in which the light kills the species in question under these conditions.

For comparison, it is stated that Bacillus prodigiosus is killed after approximately 1 minute under the same conditions

and is evidently weakened by illumination of 1/2-1 second.

From my experiments it is clearly evident

1. that the species of fungi and molds examined can all be killed by a sufficiently strong light,

2. that their resistance to light is much greater than that of Bacillus prodigiosus (and the other bacteria examined at the Light Institute, see p. 93), as well as

3. that the resistance is significantly greater in the pigment-forming species (Torula, Cladosporium, and Aspergillus niger) than in the non-pigmented ones (Saccharomyces apiculatus and Monilia candida).

VI.

Do the different species of bacteria have the same resistance to light?

Axel L. Larsen.

In order to investigate whether individual bacterial species have different resistances to the killing effects of light, it is best to use a constant light. If an inconstant light is used, such as sunlight, one can, of course, expose cultures of different bacterial species simultaneously and under the same conditions. However, in this way one can only conduct a qualitative investigation into whether there is a difference in the resistance of the individual bacterial species, as well as form a reasonable idea of the magnitude of this difference.

By frequently measuring the light intensity, one achieves some certainty, but this is not complete, since there is no actinometer that reacts exactly like bacteria.

For example, if two species are illuminated simultaneously, one dies after 6 hours of illumination, the other after 8 hours

killed, one can only conclude that they have different resistance; the last 2 hours of illumination cannot be compared with any of the periods of the previous 6 hours.

If one wants to be precisely informed about the conditions, one must conduct a quantitative investigation using constant artificial light.

Of the researchers who previously investigated the bactericidal effect of light, very few worked with constant artificial light, and none of them dealt with the conditions discussed here. And of those who used the sun as a light source, only Buchner illuminated cultures of different species simultaneously, namely Bacillus tyfosus, B. coli communis, and B. pyocyaneus; he found no clear difference between their resistance. A few others have investigated different species at different times; from this, as can be seen from the above considerations, no conclusions at all can be drawn

Therefore, highly accurate, comparative investigations into the effect of light on various bacteria are needed, and I conducted precisely such investigations. For the time being, I have only examined a few species, as I selected them from the large group of bacteria; however, I hope to be able to publish experiments with a larger number of species later.

I have set up my experimental technique in such a way that I can compare experiments carried out at different times. First, as far as the light source is concerned, I used an electric arc light. The lamp I used during the experiments ranged from 35 amps and 46 to

44 volts, and the current intensity was controlled by an ammeter. I always used the same carbons to produce the light

The light was concentrated using a collecting apparatus of an older design by Professor Finsen. I used this apparatus for all investigations, so that the amount of light was always the same.

To further check this point, I frequently attempted to determine how much time was needed to kill and weaken Microc. prodigiosus, and each time this time was constant, namely 35 minutes and 15 seconds, respectively.

After these explanations, I can consider it proven that the light intensity was always the same. The bacteria were sown from broth cultures into liquid agar, which I allowed to stiffen in a thin layer on one of the inner sides of a small rectangular bottle.

The same amount of agar was used for each experiment, namely 2 cc, and the bacteria were distributed as evenly as possible

Seeding in the liquid agar was carried out when it had a temperature that was not detrimental to the bacterial species under investigation. A number was drawn on the outside of the flask with asphalt varnish, which, when the flask was illuminated, shaded part of the bacteria. To prevent the influence of heat, the illuminated part of the flask was continuously sprinkled with cold water for the duration of the experiment.

The technique is therefore the same as that used by Finsen. By pouring a certain amount of agar onto one side of the flask (the flasks are all the same size),

1) N. R. Finsen: On the Application of Concentrated Chemical Light Rays in Medicine. Leipzig 1899, p. 19 (Vogels Verlag).

This ensures that the light passes through a layer of agar of equal thickness in all experiments. Refraction of light is avoided because the sides of the flask are flat, and the corners and edges of the flask are not illuminated at all, but form part of the unlit section of the flask used for control purposes.

This section, as well as the agar under the black number, has the same effect here as the control tubes in the investigations of the earlier authors and is more reliable, since it shows that the cultures are viable precisely in the illuminated flask.

It goes without saying that the flask was placed in such a way that the light fell at a right angle onto the illuminated part of it.

I considered the criterion for the bacteria being killed to be the fact that the illuminated part of the agar remained sterile, even after the flask had stood in a thermostat at a temperature favorable for bacterial culture, until the culture in the unlit part had grown strongly

Before I proceed to describe my experiments, I will briefly explain the terms used in the tables. On one side of which are listed the experiments intended to determine how much time the light needs to kill the bacterial species under investigation, while on the other side it is stated how long the light must act on to weaken its growth.

By "action," I understand the inhibition of the growth of the bacteria, visible to the naked eye, after they are illuminated. The action is called "just visible" when, after a certain time, the bacteria located under the black number in the shadow have grown a little more than the illuminated ones, so that the

The difference can only be discovered by very close inspection. With the term "visible exposure," this difference is somewhat greater, but by no means noticeable, which is the case when the exposure is described as "distinct." "Strong exposure" indicates that some of the sown bacteria have been killed, but that numerous others are still growing. "Very strong exposure" means that most of the bacteria have been killed; if the exposure is described as "killed," this means that none of the illuminated bacteria have grown at all after the culture flask has been in the thermostat.

Furthermore, I would like to point out that when it is necessary to investigate how much time the light needs to inhibit the growth of the bacteria, one must sow densely and check the culture frequently, since the difference between the illuminated and unilluminated sections can only be noticed when the growth has reached a certain intensity—a circumstance that, of course, gradually evens out

The following species were examined: Bacillus pyocyaneus, cyanogenus, Typhi muris, Typhi, Bacillus coli commune, as well as Staphylococcus pyogenes albus, aureus, and citreus.

1.

Bacillus pyocyaneus.

Number of trials	Illumination time in min.	Exposure	Number of trials	Illumination time in sec.	Exposure
1	20	Severely killed	2	5	None
4	25		4	10	Visible
			5	20	
			2	30	Clearly

II.

Bacillus cyanogenus.

Number of trials	Illumination time in min.	Exposure	Number of trials	Illumination time in sec.	Exposure
1	20	Strongly	2	5	None
4	25	Killed	6	10	Barely visible
			6	15	Clearly

III.

Bacillus typhi muris.

Number of trials	Illumination time in min.	Exposure	Number of trials	Illumination time in sec.	Exposure
1	30	Strong	2	5	None
1	40	Strong	2	10	Visible
1	45	Very strong	2	20	Visible
4	60	Killed	1	30	Clearly

IV.

Bacillus typhi.

Number of trials	Illumination time in min.	Exposure	Number of trials	Illumination time in sec.	Exposure
2	30	Strongly	3	5	None
3	45	Killed	3	10	Visible Visible
			3	15	

V.

Bacterium coli commune.

Number of trials	Illumination time in min.	Exposure	Number of trials	Illumination time in sec.	Exposure
2	30	Strongly	4	10	None
4	35	Strong	4	20	None
2	40	Very strongly	4	25	None
4	45	Killed	4	30	Barely visible
			4	40	Visible

VI.

Staphylococcus pyogenes aureus.

Number of trials	Illumination time in min.	Exposure	Number of trials	Illumination time in sec.	Exposure
3	30	Strongly	2	5	None
5	35	Killed	2	10	Just visible
			6	20	Visible
			6	30	Clearly

VII.

Staphylococcus pyogenes albus.

Number of trials	Illumination time in min.	Exposure	Number of trials	Illumination time in sec.	Exposure
1	30	Strongly	2	10	None
3	35	Killed	3	20	Visible Visible
			3	30	Clearly
			5	40	

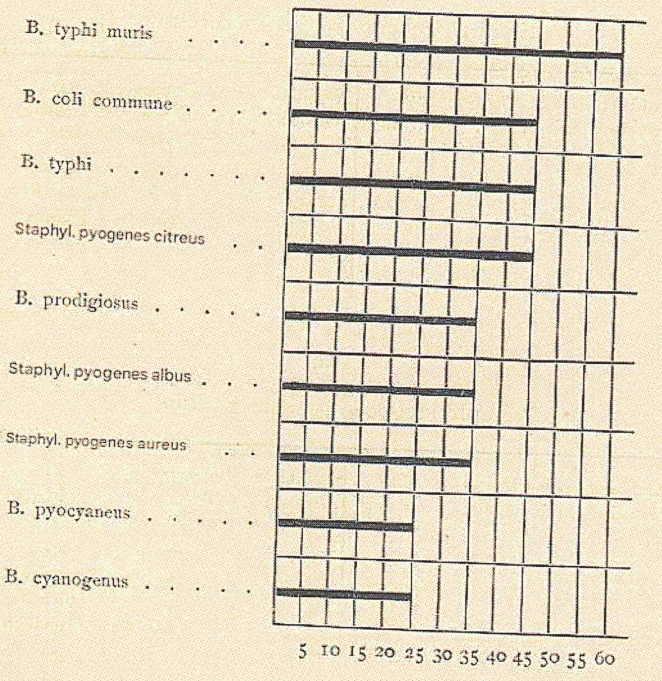
VIII.

Staphylococcus pyogenes citreus.

Number of experiments	Illumination time in min.	Exposure	Number of experiments	Illumination time in sec.	Exposure
1	30	Strong	4	20	None
1	35	Strong	4	30	None
1	43	Very strong	4	50	None
3	45	Killed	4	55	Visible

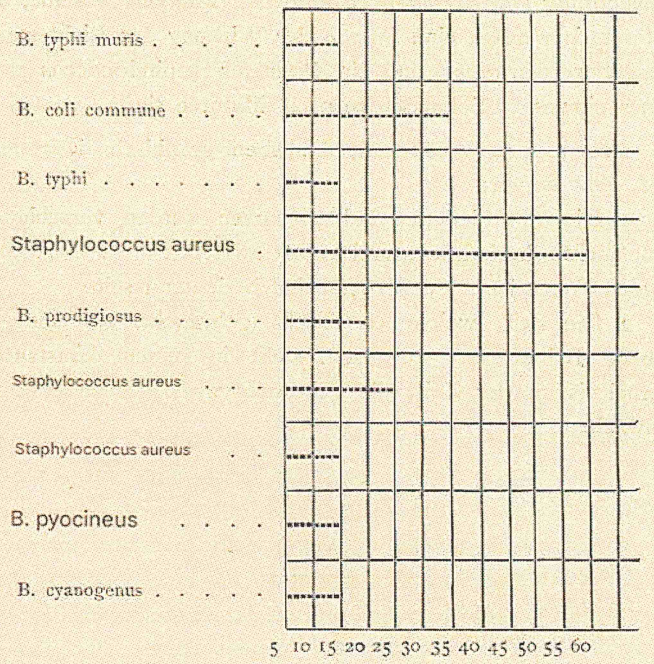
From the above-mentioned experiments, which, as stated, are only a part of a longer series of investigations on

Killed. The time is given in minutes.



this question, it is clear that just because a single species is killed by the light in a certain time, one cannot conclude that all bacteria behave in the same way. For the time necessary to kill the species I examined varies from 25 minutes to 1 hour,

Weakened. The time is given in seconds.



thus, up to more than double. Nor can one conclude that if one species of a particular bacterial form is killed in a certain time, then the other species of the same morphological group will behave similarly; e.g., one sees that Staphylococcus pyogenes albus and aureus are killed after 35 minutes, while Staphylococcus citreus must be illuminated for 45 minutes.

The time necessary to weaken the growth of bacteria in general also varies somewhat according to my experiments, fluctuating between 5 and 55 seconds, and is not proportional to the time necessary for destruction for the species examined. For example, weakening is detected in Bacteria typhi muris after just 10 seconds of illumination, while in order to be killed, it must be exposed to the light for one hour, and the times for Staphylococcus pyoogenes citreus are 55 seconds and 45 minutes, respectively.

From my experiments, which are graphically presented above, it can be seen:

1. The different species of bacteria are affected differently by light, and even between very closely related species, the difference can be significant

2. The time it takes for light to kill a given species of bacteria is not in a constant relationship to the time it takes to weaken it.

VII.

On the intensity of the sun's rays by Dr. Absalon Larsen.

If the intensity of the sun's rays outside the atmosphere is given, the intensity of the rays reaching the surface depends only on the altitude of the sun and the state of the atmosphere

As early as 1760, Bouguer formulated the theorem that the sun's rays are weakened according to a geometric progression if the air mass traversed by them increases according to an arithmetic progression. For example, if the intensity of the rays outside the atmosphere is I and the intensity of the part of the rays reaching the Earth's surface at vertical incidence is a I, then according to Bouguer, the radiation intensity at the Earth's surface can generally be set equal to anI, where the traversed air mass means the air mass at vertical incidence taken as unity.

In 1838, Pouillet published his work on solar radiation. With the help of the pyrheliometer, he determined the radiation intensity at different altitudes above the sun and, using Bouguer's formula, came to the conclusion that the amount of heat which, at vertical

The amount of radiation supplied by the sun's rays outside the atmosphere in 1 minute at right angles to a 1 square centimeter, absolutely black surface, is the so-called solar constant, and the transmittance coefficient a is equal to 4/5.

During the years 1874-79, Viole undertook numerous experiments on solar radiation using an improved apparatus, the actinometer, whose heat-sensitive part consisted of a blackened thermometer vessel. To protect against air currents and to allow greater regularity of radiation, the vessel was surrounded by a double-walled sphere, the cavity between the two spherical shells of which water flowed. An opening on one side allowed the rays to reach the thermometer. Viole gives the value of 2.54 calories for the solar constant

In his great work, 1) Langley points out that Bouguer's formula is only valid for individual types of rays, and that when applied to all radiation, the solar constant must always be too small.

Langley's work on solar rays must still be considered the most important in this field. Using a rock-salt prism and concave mirror, or in other cases with a Rowland grating, he resolved the rays into their individual components and, with the bolometer he invented for this purpose, measured the heat effect of the various types of rays, from rays of wavelength 0.35 (ultraviolet) to rays of wavelength 14.0 (ultrared), and later even further into the ultrared to rays of wavelength 34.0, the existence of which was first postulated by Langley.

1) Researches on solar heat and its absorption by the earth's atmosphere. A report of the Mount Whitney expedition. Washington 1884

was demonstrated. By comparing the energy spectra of the sun's rays obtained in this way at different altitudes above the sun, it was found that the transmission coefficient varies greatly with wavelength, in such a way that the violet rays are attenuated the most and the red rays the least when passing through the atmosphere. The following table lists the transmission coefficients found by Langley in Alleghany in the years 1880-81:

Wavelength:								
0.375	0.400	0.450	0.500	0.600	0.700	0.800	0.900	0.00
Transmission Coefficient:								
0.39	0.42	0.48	0.54	0.64	0.71	0.76	0.79	0.80

From this table, for example, it can be seen that of certain ultraviolet rays, with perpendicular incidence, only 39 percent reach the Earth, whereas under the same conditions about 70 percent of the red rays and about 80 percent of certain ultrared rays reach the Earth.

After Langley had arrived at these important results, he undertook a scientific expedition to Mount Whitney, a mountain in the Sierra Nevada, where, assisted by numerous collaborators, he collected a wealth of observational material in August and September 1881, partly at the foot of the mountain 3,700 feet above sea level and partly on a lofty peak 11,600 feet above sea level. This material he processed after his return to Allegany and supplemented with additional experiments

Regarding the hike from the station at the foot of the mountain (Leon Pine) to the summit, Langley writes that even without any use of instruments, the change in light was easily noticeable. The color of the sky appeared far more dark blue and violet. And the skin of the face

and the hands were severely attacked by the rays, although the air was cold and the skin had long been exposed to the burning sun's rays at the low station. 1)

Some numerical values of the experimental results are reported in the following table according to Langley. The

Place of observation	At the foot of the mountain			At the summit			
Altitude above sea level	3760 feet			11625 feet			
Barometer reading	662 mm			499 mm			
Air mass	717	1414	2152	572	746	1128	2300
Wavelength = 4.350	25.1	10.0	0.0	39.9	14.8	16.3	5.1
— 0.375	28.4	15.7	4.0	4.3s	23.2	20.3	12.8
— 0.400	50.1	29.6	12.4	71.5	68.0	42.1	35.3
— 0.450	110.6	88.3	71.1	174-2	162.5	149.3	118.5
— 0.500	153.9	129.5	117.6	229.0	214.4	203.2	160.0
— 0.600	201.0	177.0	160.7	249.7	240.4	228.1	183.5
— 0.700	191.1	180.7	162.5	214.8	218.3	204.6	176.1
— 0.800	155.5	151.7	134.3	159.4	165.3	157.9	136.9
— 1.000	100.2	94.6	82.1	100.4	100.4	94.7	81.1
— 1.200	76.4	58.5	51.4	72.1	69.1	60.0	49.1
— 1.400	58.0	44.4	38.8	56.1	50.5	43.8	32.7
— 1.600	42.5	32.7	28.6	42.7	37.8	33.3	24.1
— 1,800	29.6	22.9	20.0	30.8	27.3	23.8	17.2
— 2,000	18.3	14.7	12.9	20.4	18.7	15.8	11.4
— 2,200	10.1	7.9	6.9	11.4	10.5	9.0	6.6
— 2,400	3.2	2.5	2.2	3.8	3.6	3.2	2.6
Total heat in relative mass 75-00	64-85	56.96	83-85	80.67	74-15	60.51	

Columns indicate the heat effect of the various types of rays, i.e., the energy distribution in the spectrum. The different columns correspond to the various external

envy

1) Compare with this the experiments of Prof. Finsen on the effect of ultraviolet rays. This booklet page 8.

circumstances, the altitude above sea level, and the path traveled by the rays through the air, which is given as the air mass. For example, "air mass 717" means that the column of air irradiated by a beam of rays has the weight of a column of mercury of the same thickness and 717 mm in length

Let us first consider the numbers in the first and third columns. The former indicate the intensity of the rays after passing through an air mass of 717, which, at a barometer reading of 662, corresponds to a high solar altitude. The latter show the intensity of the rays after passing through three times the air mass, i.e., at a low solar altitude.

All rays have been weakened by the increased air mass, but to very different degrees. The ultraviolet rays of wavelength 0.35 μm have been completely absorbed. The violet rays of wavelength 0.375 μm have been reduced from 28.4 to 4.0 μm, i.e., to approximately 17%, the blue rays of wavelength 0.40 to 1/4, and the red rays of wavelength 0.7 to 4%. The numbers in the last four columns, relating to the observations at the summit, show a very similar behavior The ultraviolet and violet rays have been attenuated the most, the red and ultrared the least; but the decrease in intensity is smaller at the summit than at the foot of the mountain for the same increase in air mass. This shows that a given mass of air in the upper part of the atmosphere exerts less absorption than an equal mass of air in the lower part of the atmosphere. This difference is particularly considerable for rays of short wavelength.

According to what has been said, sunlight is not only attenuated as a whole by the absorption of the atmosphere, but its composition is also changed. Langley compares the sun seen through the atmosphere with that seen through

Electric light seen through a red-yellow glass. Someone who had seen only such light in his entire life would call it white light. But if, after removing the glass, the electric light shone in its full glory, it would appear blue to him, just as the sun appears to us if we could observe it from a point outside the atmosphere...

The higher the sun is in the sky and the higher one rises above sea level, the more powerfully the blue and violet sunrays will emerge, all other things being equal.

Langley's investigations were carried out under the most favorable atmospheric conditions possible. The air was perfectly clear, the sky cloudless. Only exceptionally would one find equally clear days here. Langley calculates the solar constant from his experiments and arrives at an even greater value than Violle, namely 3 cal

In Europe, Crova has been conducting investigations into solar radiation in Montpellier for several years. His curves, recorded with a self-recording apparatus, are of particular interest, as they clearly represent the solar radiation that actually reaches the Earth's surface at any time of day and on any day of the year. The heat-sensitive part of the apparatus consists of a thermocouple, one soldering point of which lies in the shade, while the other is exposed to the rays and is always directed towards the sun by means of a heliostat.

Figs. 1 and 2 show two curves recorded by Crova simultaneously in Montpellier and on Mont Ventoux.

-1971) Mémoires de l'Académie de Montpellier. October 10, 1884.
Donab Annales de Chimie et de Physique. (6) October 14, 1888 and February 21, 1890.

reproduced. The two curves show a depression at noon, and as can be seen, the noon ordinate divides the curves asymmetrically. This probably stems from the changing water vapor content of the atmosphere. The many quite considerable rapid fluctuations in the intensity of solar radiation are more pronounced at the low station than on the mountain. The weather was perfectly clear at both locations. Crova therefore believes that these fluctuations are due to movements of water vapor in the atmosphere. They are more pronounced in summer and on warm, calm days than in winter and on days with a fresh wind.

In Kiev (Russia), Savelief obtained very similar curves. 1)

Recently, K. Ångström has undertaken absolute measurements of solar radiation using new apparatus 2). No report has yet been given on the results.

While only those investigations relating to the heating effect of the sun's rays have been mentioned above, a number of other works exist on the chemical effects of the rays

Bunsen and Roscoe worked with a hydrogen chloride photometer. A mixture of equal parts of chlorine and hydrogen was sealed above water in a glass vessel. Under the influence of the sun's rays, hydrogen chloride was formed, which was absorbed by the water. This caused a reduction in the gas volume, which could be read off in a narrow tube. The reduction in the gas volume was taken as a measure of the chemical energy released by the rays. The results of Bunsen and Roscoe's measurements, as well as a detailed description,

1) Comptes rend. de l'Acad. des Sciences. CX, page 235. 1890.
2) Annalen der Physik und Chemie 67, page 633. 1899

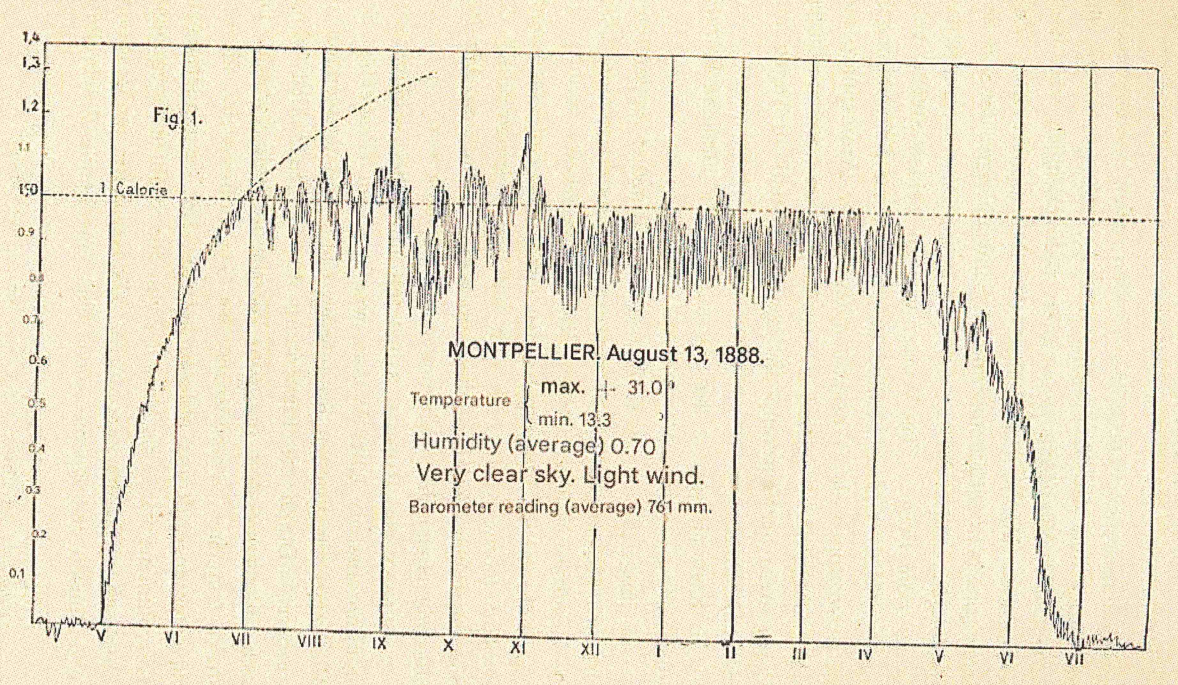


Fig. 1.

MONTPELLIER. August 13, 1888.

Temperature { max. + 31.0°
min. 13.3

Humidity (average) 0.70

Very clear sky. Light wind.

Barometer reading (average) 761 mm.

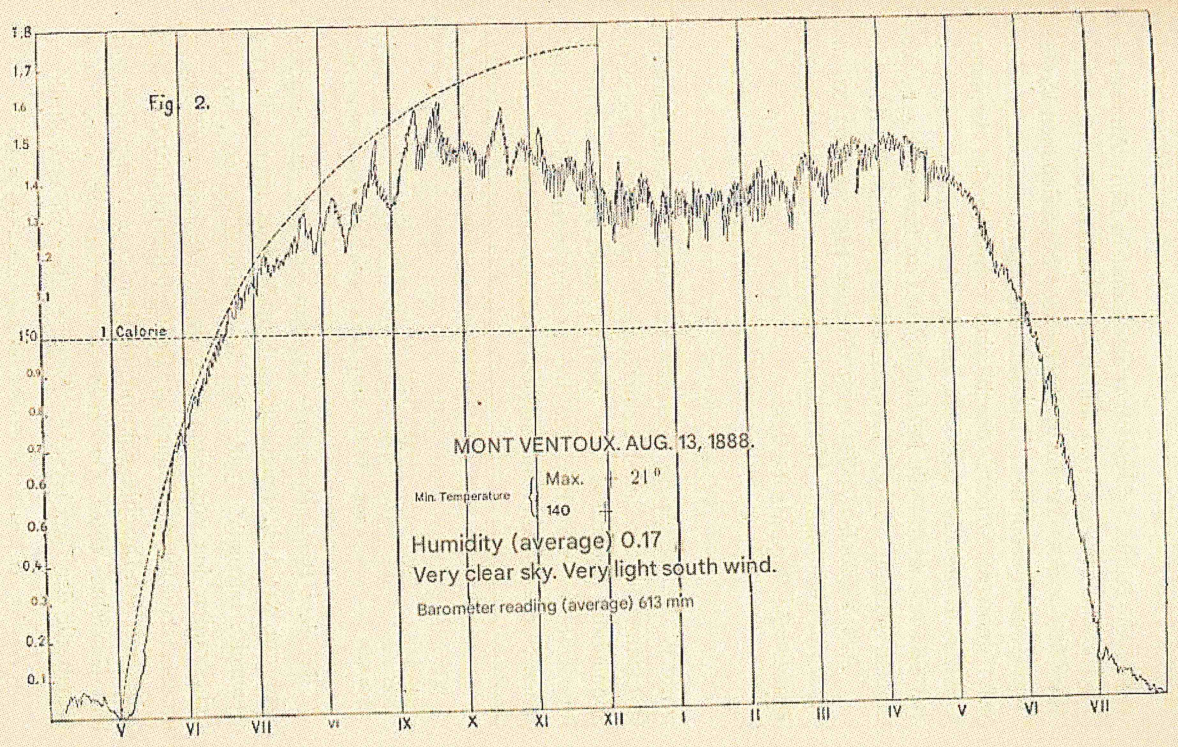


Fig. 2.

MONT VENTOUX. AUG. 13, 1888.

Min. Temperature { Max. + 21°
140 +

Humidity (average) 0.17

Very clear sky. Very light south wind.

Barometer reading (average) 613 mm

The method and conclusions can be found in the "Annals of Physics and Chemistry"[1]). The light from a more precisely described carbon monoxide lamp was taken as the unit of chemical intensity. The carbon monoxide flowed out into the air under very low pressure through a 7 mm wide circular opening. With a gas consumption of 5 cc per second, the exposure at a distance of 1 m was called 1 light unit. 10,000 light units give 1 degree of light.

From experiments carried out on August 3, 1857, and on September 14 and 15, 1858, in Heidelberg, Bunsen calculated the following formula

$$W = 318.3\ 10^{\frac{0.4758\ P}{\sin h}}$$

where W is the chemical intensity of the direct sun's rays in light degrees, P is the barometer reading in meters, and h is the altitude of the sun. From this formula, the following table can be calculated for the intensity at different barometer readings and different altitudes of the sun.

	90°	80°	70°	60°	50°	40°	30°	20°	10°	0°
750 mm	139.8	138.2	132.7	123.2	108.9	88.1	61.5	28.8	2.8	0.0
600 mm	165.9	163.3	158.1	149.0	135.6	114.5	85.5	46.6	7.2	0.0
450 mm	194.4	193.0	188.4	180.1	167.2	147.8	118.8	75.3	18.6	0.0

At a barometer reading of 750 mm and a sun altitude of 90°, i.e., perpendicular incidence, one finds, for example, a chemical intensity of 139.8. At a sun altitude of 300°, where the light rays have to travel twice the distance through the air, the intensity is only 61.5. The quotient $61.5 \times 139.8 \times 0.44$ then gives the transmittance = coefficient of a layer of air with the weight of a 750 mm column of mercury. This agrees with Langley's statement on violet rays,

1) Annalen der Physik und Chemie 108 pp. 191-273. 1859.

according to which 42% of the rays with a wavelength of 40 penetrate the atmosphere at normal incidence.

Later, Roscoe conducted further experiments on the chemical intensity of the sun's rays. The results, as far as direct sunlight is concerned, largely agree with those already mentioned. But his method is quite different and is based on the effect of the rays on photographic paper. 1)

The blackening of the paper is directly or indirectly compared with suitable standard colors. The method was further developed through the construction of a self-registering apparatus. 2)

Wiesner has also recently worked with photographic paper. In particular, the latter has collected a great deal of material for determining the chemical power of scattered daylight through daily measurements

For the application of direct sunlight in light therapy, it is of practical importance to know both the thermal effect and the chemical effect of the rays at every time of day and year. This can initially only be calculated from the results obtained so far, assuming completely clear weather, and further assuming that the air pressure is constant at 760 mm and that the water vapor content of the atmosphere is the same as in the experiments mentioned. Under these conditions, the following two tables on the thermal effect and the chemical effect of direct sunlight in Copenhagen are calculated: the former from Langley's experiments, the latter from Bunsen's formula.

1) Annalen der Physik und Chemie, Vol. 117, page 529, 1862, and Vol. 128, page 291

2) Annalen der Physik und Chemie, Vol. 151, page 268, 1874. 3)
WIESNER: "Investigations into the photochemical climate of Vienna, Cairo, and Buitenzorg (Java)." Vienna 1896

The Warming Effect of Direct Sunrays in Copenhagen.

Time AM / PM	12	11 / 1	10 / 2	9 / 3	8 / 4	7 / 5	6 / 6	5 / 7	4 / 8
December 21	33	31	22	7					
January 20	40	38	31	18					
February 19	55	54	48	39	22				
March 21	65	65	61	55	45	26			
April 21	71	70	68	65	59	48	31	5	
May 21	73	73	71	69	64	57	45	27	4
June 21	74	74	72	70	66	60	50	34	13
July 21	73	73	71	69	64	57	45	27	4
August 21	71	70	68	65	59	48	31	5	
September 22	65	65	61	55	45	26			
October 22	55	54	48	39	22				
November 21	40	38	31	18					
December 21	33	31	22	7					

The Chemical Effect of Direct Sunrays in Copenhagen.

Time AM / PM	12	11 / 1	10 / 2	9 / 3	8 / 4	7 / 5	6 / 6	5 / 7	4 / 8
December 21	4.5	2.5	1.7	0.4					
January 20	12.7	9.9	2.8	1.4	0				
February 19	38.7	34.9	23.8	10.3	1.7	0			
March 21	72.3	68.4	58.3	39.3	18.3	2.1	0		
April 21	100.6	97.6	87.9	71.9	49.6	23.1	2.6	0.3	
May 21	114.6	112.1	104.9	89.8	49.9	44.7	18.7	2.2	0.2
June 21	118.8	116.5	109.9	95.8	76.7	52.6	25.7	5.3	1.6
July 21	114.6	112.1	104.6	89.8	69.9	44.7	18.7	2.2	0.2
August 21	100.6	97.6	87.9	71.9	49.6	23.1	2.6	0.3	
September 22	72.3	68.4	58.3	39.3	18.2	2.1	0		
October 22	38.7	34.9	23.6	10.3	1.7	0			
November 21	12.7	9.9	2.8	1.4	0				
December 21	4.5	2.5	1.7	0.4					

These two tables are not directly comparable, but the pattern of the numbers is. Let us first consider the data in the tables for June. The heat effect is 74 at noon and only drops to about half by 7 a.m. The chemical effect, on the other hand, which is 118.8 at noon, has already dropped to less than half by 5 p.m. and is only 5.3 at 7 a.m., which is 1/20 of the amount at noon. The same difference in change is also noticeable in the two columns for noon in the different months. It follows that for purposes involving the use of the chemical power of the sun's rays while avoiding an overly strong heat effect, only the midday hours and the summer months are favorable. It would certainly be possible to increase the chemical effect through greater concentration even when the sun is low in the sky, but at the same time the heat effect would reach too significant a value

In addition, there is the cloud cover not taken into account above, which precludes regular use of direct sunlight even during the summer months. To get an overview of how many hours per day the sun shines on average in Copenhagen, the table on the next page is calculated from a relevant graphic representation in the monthly report of the Danish Meteorological Institute.

In winter, the sun is uncovered for only a small fraction of the daytime hours. In summer, it shines for an average of one-third of the total daytime hours. In both winter and summer, there are days when the sun shines almost continuously from sunrise to sunset. As a rule, however, it only appears temporarily (for 14 or 1/2 hours), alternating with more or less long periods of shadow

	Number of daylight hours	Average Number of sunshine hours per day			Greatest number of sunshine hours in one day		
		1896	1897	1898	1896	1897	1898
January	7:40 a.m.	0.7	0.5	0.2	5.7	4.1	2.7
February	9:28 a.m.	1.6	2.3	0.9	7.4	7.6	6.1
March	11:30 a.m.	1.3	1.3	1.7	5.4	8.1	8.8
April	2:18 p.m.	3.8	4.3	—	11.4	10.4	—
May	4:12 p.m.	6.9	5.7	—	12.0	13.2	—
June	5:19 p.m.	7.7	5.5	5.6	12.6	11.8	12.8
July	16h 40m	4.6	3.6	5.3	11.2	11.8	14.3
August	15h 0m	4.4	3.7	5.0	10.3	10.9	12.1
September	12h 40m	4.1	4.1	4.8	9.7	10.1	10.2
October	10h 18m	1.6	1.8	2.1	6.0	8.4	8.6
November	8 20	1.0	1.2		7.2	6.9	
December	7 3	0.7	0.3		5.4	3.9	

From this it can be seen that Denmark leaves much to be desired with regard to the use of the chemical effects of direct sunlight. Here, as in northern and central Europe in general, preference is given to electric arc light in this regard.

VIII.

Some cases of alopecia areata treated with concentrated chemical light rays.

Preliminary communication

by

O. Jersild.

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This treatise was published simultaneously in Annales de Dermatologie No. 1, 1899

At a demonstration conducted at Dr. Forch-Hammer's medical society involving 50 lupus patients who had been treated at Finsen's Medical Light Institute, a large number of results from this new therapy were presented to the Copenhagen medical world for the first time—the results, it should be said, exceeded even the wildest were many old — patients, among whom — expectations. The 50 lupus ulcerative cases, all presented with beautiful white, often barely visible cicatricial lesions, and even upon the most careful examination, no nodules or infiltrations could be detected in the skin. The scope of Finsen's invention can still hardly be determined; however, this much is certain: a method here Finsen's Medical Light Institute. 8

which opens up broad therapeutic, especially dermatotherapeutic, future prospects.

There is no doubt, as the investigations of Finsen 1) and his collaborators 2) have proven, that chemical light rays in concentrated form are among the most effective bactericidal agents known to man, and that their effect penetrates deep into the tissue without altering it or causing harmful side effects. A more ideal treatment for parasitic skin diseases can hardly be imagined. The requirements that must be placed on the light are, first, that it be strong enough; second, that heat rays are excluded as much as possible; and finally, that it is applied for a sufficiently long time

One condition particularly suited to treatment of this kind is alopecia areata. As is well known, the dispute over the etiology of this affection is long-standing, but, as far as one can judge, even earlier anti-contagionists in Germany seem to have subscribed to the long-defended infection theory of the French dermatological school. In this regard, it is interesting that Lesser, in his latest edition of The Textbook of Skin Diseases, in contrast to his earlier view of the disease as a completely nervous affliction, now recognizes two forms: the trophoneurotic and the parasitic. It is remarkable that this admission is coming so slowly, especially when one considers the convincing and epoch-making work that has come from France (Sabouraud et al.) in recent years on the question of etiology

1) FINSEN: On the application in medicine of concentrated chemical light rays. Leipzig 1899.
2) See Bies and Larsen's article.

I am not blind to the need for as much material as possible to draw conclusions regarding therapeutic results, especially when dealing with a condition that, like alopecia areata, tends toward spontaneous recovery, certainly often only after it has existed for years. Since the condition is quite rare in this country, we have considered it most correct to draw attention now to this treatment, which will hopefully prove to be rational; otherwise, several years might pass before sufficient material would be available

I collected my cases in the department of skin diseases at the polyclinic; some of them were sent by private physicians. All patients were treated at Finsen's Medical Light Institute.

I would like to express my sincere thanks to Professor Finsen for his kind kindness and for permission to publish the cases, and to my supervisor at the polyclinic, Dr. Ludwig Nielsen, for providing the patients.

It is never a good sign when the number of treatments and remedies proposed for a condition is large. As for alopecia areata—a disease whose treatment has particularly absorbed the attention of physicians—one has only to consult the larger manuals to see that the results have scarcely corresponded to the ingenuity and effort applied. This is also admitted by most dermatologists, who consider therapy completely powerless against the disease mentioned here and place their hope in time and its spontaneous recovery. To cite just one 8*

cite a few examples, KAPOSI says: 1) "Therapy seems to be based on this disease, but is entirely positive and, as empirically as possible, of all certainty; it cannot be prolonged, nor can it be determined that it will break at a new point. — To The rest time seems better than anything that can be done," and LESSER 2) claims that there is no remedy that can stop hair loss or promote new hair growth and suggests the commonly used remedies "out of aliquid fiat." All the various French methods (VIDAL, BESNIERS' treatment, etc.) have two main aspects in common: 1. the local application of irritants and 2. general prophylactic antiseptic treatment of the scalp. SABOURAUD[3], who, as is well known, identified a possibly specific form of bacteria (microbacille de l'utricule peladique) in alopecia areata, assumes that the toxic effect of this bacterium on the papilla is responsible for hair loss. In his opinion, the application of local irritants is rational because it facilitates the excretion of stagnant, harmful metabolic products. In contrast, antiseptics are said to be ineffective on the patch itself, as they do not penetrate deep into the scalp.

If we seek clarification about the results of these treatments recommended from France, we find the following in Brocq: 4) The treatment by M. Dr. E. Vidal gave us rapid results: it can cause a characteristic peeling by medium-large plaques.

1) M. Kaposi: Pathologie et traitement des maladies de la peau. Translated by E. Besnier and A. Doyon. 2nd edition, II. Paris 1891, pages 194–196.
2) Lesser: Lehrbuch der Haut- und Venerealkrankheiten I. Leipzig 1896
3) SABOURAUD: Clinical and experimental study on the origins of skin eczema. Ann. de dermatologie 1896.
nis 4) BROCQ: Treatment of skin diseases. Paris: 1892.

in three to six months; it is almost the same as that of M. and Dr. E. BESNIER.

The fastest French methods therefore last at least 3-6 months

Before I proceed to give a brief account of the case reports, I consider it most correct to emphasize the properties of light on which the treatment of what I consider to be a parasitic condition, "vulgaris pimples," i.e., the infectious, sometimes epidemic form of alopecia areata, is based, and to give a brief description of the procedure that was used here.

The factors in the effect of light that are initially of decisive importance are:

1. The bactericidal, deep-penetrating effect of light.
2. The hair-growth-inducing effect of light.
3. The induction of local skin inflammation by light

1. The bactericidal effect of light has been proven by numerous investigations (Downes and Blunt, Duclaux, Arloing, Geisler, Buchner, D'Arsonval, and Charrin); the deep bactericidal effect is proven by Finsen's experimental investigations, 1) as well as by the tangible results of lupus treatment.

2. As far as I know, there are only a few studies by one author in the literature on the influence of light on the growth 2) of nails and hair, according to which light is supposed to promote hair growth. Some popular

1) Finsen: 1. c. p. 29. Bibliographies included. 2) Bertold: Müller's Arch. f. Anatomie und Physiologie. 1850, p. 156 .

Observations, which I mention in passing, without attaching much importance to them, seem to point in the same direction. It is an old, well-known popular observation that shaving and cutting hair are more often necessary in summer than in winter; furthermore, it is generally known that it is much easier to grow a full beard in the southern zones than in our northern climate. However, there are also actual clinical observations in this regard; for example, it is a fact, which I can substantiate with some journal excerpts, that one often sees more abundant hair growth in the area of light-treated lupus lesions than in other parts of the skin.

Case report I. K. R., 21 years old, unmarried woman. Lupus erythema. Treatment began in 1996

On January 16, 1997, it is noted: The spot on the right cheek is surrounded by a fringe of strong hairs; these only developed about a month ago, when the spot was healed. The spot was treated with electric light for only 4 hours during the first few days of September.

Case report II. E.R., 9 years old, daughter of a pilot. Lupus vulgaris. Treatment began in 1996.

On January 15, 1997, it is noted: The hair growth (the lanugo hairs) outside the cicatrice on the healthy skin is more abundant than on the rest of the skin.

On April 14, 1997, there is some pigmentation of the healthy skin around the previously affected spot, and there is an abundant growth of lanugo hairs.

On April 24, 1997, the hair growth is more abundant around the edge of the cicatrice, especially downwards and backwards, than on the rest of the cheek

These observations, compared with the statements of the nurses working at the light clinic, according to which their arms, exposed to the strong electric lighting, grow more hair than before, seem

to support the view that the light has hair-growth-stimulating properties

3. There is no doubt that the vigorous application of irritating agents and the resulting skin hyperemia 1) are largely responsible for the results the French authors claim to have achieved with their treatments. In the light treatment of alopecia areata, local dermatitis is certainly also a factor of some importance. That redness and subsequent exfoliation — because of the skin, and in more severe cases even bulla formation, can be caused by the action of the light rays is observed daily at the institute. However, it must be emphasized that the local reaction in almost all cases remained within the limits of the slightest skin inflammation, and one can therefore hardly assume that it played a significant role in the results achieved

All cases were treated with electric light (arc lamps of 50-80 amps). I cannot say whether sunlight possibly has a stronger effect; from the outset, I am inclined to assume it is analogous to the results in the treatment of lupus.

The apparatus is known from Finsen's earlier communications, to which I refer; 2) I only add that all cases of alopecia were treated with the latest apparatus using rock-crystal lenses.

1) It is quite interesting that the latest French treatment for alopecia areata (Jacquet: Traitem, de la pelade par l'irritation aseptique simple. Ref. i Sem, méd. 1898 No. 26) aims to induce the desired skin hyperemia by mechanical means (brushing the spot and its surroundings).

See, incidentally, Sabouraud's previously cited interpretation of the effect of local irritants,

-150 2) Finsen: 1.7c.ni stall

I will give a brief description of the treatment of the spot itself. In order to be able to influence the actual growth zone directly and unhindered, we shaved the area surrounding the spot to a circumference of approximately 1.5 cm; epilation was not used. The entire spot and the shaved zone were then illuminated in daily séances, usually lasting 5.5 hours. With larger spots, we occasionally had two séances in one day. When the entire spot had been illuminated (the time required for this is, of course, proportional to the size of the spot), the treatment ended, and another spot was treated. Once all affected areas had been illuminated once, the patient was dismissed with a request to return for observation

To prevent the spread of the disease, the healthy parts of the scalp were treated with daily soap and sublimate washes. Infected headgear was naturally confiscated, and orders were given to disinfect combs, hairbrushes, and the like. The use of sponges for washing was also prohibited. This was done with hygroscopic cotton swabs; these are thrown away after use.

Finsen has shown that an important condition for the deep action of chemical light rays is that the affected area be drained of blood as much as possible. For this purpose, pressure glasses are used at the Light Institute. In the first cases of alopecia areata treated, compression was also used on the patch; however, in those treated later, it was not necessary to drain the skin, probably because the bacteria in alopecia take up residence in far more superficial areas

superficial layers, such as the tubercle bacilli have in lupus skin diseases.

Since it is impossible to completely exclude heat rays, cooling of the illuminated skin areas is necessary. The pressure apparatus used consists of two rock crystal plates set in a metal ring, between which cold water is introduced. When the pressure apparatus is not in use, the skin can be cooled by occasionally moistening it with cold water.

The treatment is completely painless if carried out correctly.

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Case reports.

I. Philipp H., 15 years old. The son of a tailor. Started on 3/9/97.

History: No information about infection. The disease was noticed at the beginning of June; at that time it was a bald spot 1 cm in diameter that had been constantly growing

Status praes: A completely bald patch measuring 6 x 4 cm between the ear and the midline of the head. The lowest edge of the patch a few cm below a line corresponding to the uppermost edge of the ear. Bulbous thickening of the hair.

Treatment began: 3/9 97

Treatment ended: 249 97 after 8 séances of 1/2 hour each.

4/10 97. Fine lanugo hairs on the patch.

5/11 97. Normal hair growth, no bulbous thickening of the hair.

12/1 98. Rec. in loco. A 2.5/2.2 cm area where there is no hair, tapering downwards, remains.

Treatment will be resumed on 12/1 98.

Treatment ended on 16/1, after 5 séances of 1 hour each

22, 98. Fine, small hairs on the aforementioned triangle.

29, 98. No hairs are found on the scar 1); otherwise, the hair growth is just as strong as on the rest of the head.

11/7, 98. Always a clean scar after the burn. Incidentally, a completely thick hair growth; no loose hairs.

21/10, 98. Always unchanged. Thick hair of normal color.

Observation period approximately 9 months after the interruption of treatment.

II. Mette N., 52 years old, married to a tailor. Beginning on 24, 98.

History: No information about infection. The condition began shortly before Christmas with a spot above the left ear. The spot has continued to grow. Only soap washes (naphthol soap) have been used.

Status praes: A spot 85 cm above the left ear, almost completely hairless

2. A spot 33 cm above the right ear.

3. A spot 22 cm on the vertex.

The treatment began: January 24, 1998.

The treatment ended on February 14, 1998 after 29 séances of one hour each.

In the 29 séances, spots 2 and 3 were treated, as well as the anterior edge of spot 1. No strong reaction, only some redness.

January 1, 1998. The patient has not returned so far.

Spot 2: recovered.

Spot 3: likewise.

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1) A bulla 2 cm in diameter appeared upwards and inwards after treatment of the shaved area. It left behind a scab, which was sloughed off in September. The spot where it had been was red and scar-like.

Patch 1: The front part covered with fairly thick, fine, gray hairs, no hair loss.

In the part towards the back (not illuminated), the patch has spread quite significantly.

Treatment restarted: 1/7 of 98 from the rear part of the patch + further spread.

Treatment stopped: 19/98 after 14 séances.

21/10 of 98. Abundant, normal hair growth with firmly attached hairs all over the patches. The hair growth on the patches is very gray, while the remaining hair is completely black.

Observation time after the interruption of treatment: approximately 8 months for the first treated areas and approximately 3 months for the last treated patch.

III. Helge H., 15 years old. The son of an iron dealer. Started on November 11, 98

History: Books taken to an official's assistant who was said to have had the same illness. Started with spots 1 and 2 3 months ago. Spot 1 has grown particularly significantly. Treated with alcohol.

Status praes: 1. A spot 53 cm a little to the left and in front of the vertebra.

2: A spot 32 cm: just to the right of the vertebra. Loose hair around the circumference, slightly curved edges. Nostalgic

Treatment started: 1.5 1998.

Treatment ended: 22.98 after 2 séances.

27.3 1998. The suffering appears to have improved, as the hairs are natural along the edges of the spots, and there is abundant hair growth everywhere.

2.5 1998. Healthy, increasing hair growth on the old spots. 3 new spots have appeared:

3. A spot 1/2 cm in diameter, round, above the left ear.
4. A spot 1 1/2 cm in diameter, just in the vertex next to the old spot 2.
5. A spot irregularly shaped, to the right of the vertex.

Treatment started again: 2/5 98.
Treatment stopped: 27/98 after 38 séances.
13/6 98. Spots 1-5 (i.e., all spots) are covered with hair. No diseased hairs in the edges, no dandruff.

21/10 98. No trace of disease. Hair growth and hair color completely normal.

Observation period after the interruption of treatment with regard to the first spots: 8 months, with regard to the latter: approximately 5 months

IV. Agnes K., 9 years old. The daughter of a coachman. Started on April 28, 1998.

History: The illness began 8 weeks ago. Always treated at the outpatient clinic, but the condition has always spread.

Status praes: 1. Round spot, 6 cm in diameter on the neck to the left of the midline.
2. Round spot, 4 cm in the middle of the neck at the hairline.
3. Oval spot, 3 1/2 cm at the crown above the right ear.
4. Round spot, 2 cm in diameter, approximately 4 cm below and behind 3. The spots are completely hairless, smooth, and white. The hair at the edges is loose; there is a bulbous thickening of the hair in several places at the edge.

Treatment started on April 28, 1998.
Treatment interrupted on February 21, 1998 due to a femoral lesion

Treatment resumed: 6/6 98.
Treatment discontinued: 13 98 after 48 séances in total.

6/7 98. All patches are healthy with increasing hair growth.
26/7 98. The same.
21/10 98. Completely normal hair growth; no trace of the disease.

Observation period after the interruption of treatment: 4 months.

V. Johannes S., 23 years old. Student, mag. Started on 16/8 98. History: The bald patch was discovered 14 days ago. Treated with Besnier's fluid (chloral, glacial acetic acid, and ether).

Status praes: One patch 23 cm, a couple of cm to the left of the occipital region. Loose hairs at the edges

Treatment started: 16/8 98. dal Sil

Treatment ended: 18/8 after 3 séances.

26/8 98. The spot unchanged in size, slightly red. In a single spot medially and downwards, a slightly stronger redness and scaling. Individual loose hairs but no bulbous thickening.
Lively, fine hair growth.
Treatment resumed: 179/98.

Treatment ended: 22/98 after 5 séances.

21/10 98. Abundant hair growth. The hair color is lighter than the surrounding areas. On the previously mentioned area, inwards and downwards, the hair growth is always a little thinner.
Otherwise, no suspicious signs,
November 26, 1998. Good hair growth overall. The hair is still a little lighter. In an area about the size of a pea, inward and downward, the hair growth is thinner.

Observation period after the interruption of treatment: approximately 2 months.

VI. Erwin G., 8.5 years old. The son of a baker's apprentice. Started on October 10, 1998

History: The suffering lasted a few months. No treatment.

Status praes: 1. Elongated, irregularly shaped spot, 42 cm in the left parietal region, 5 cm above and a little behind the ear.

2. Round spot 1 cm in diameter in the right parietal region, approximately 10 cm above the ear.

3.6 Small spots on the neck, approximately 5 cm above the hairline, and a narrow spot in the middle of the head with — with thinning hair growth,

Cob-like thickening of the hair at the edges.

Treatment started: 10/10 98.

Treatment stopped: 24/10 98 after 13 séances.

31/10 98 Loose hairs nowhere to be found, culbre

7/11 98. No new spots. Most of the small spots are fairly well covered with hair, but still visible. The spot above the left ear has not grown; a few hairs here and there on it, these are natural. No loose hairs.

21/11 98. Most of the small spots are barely visible; the entire bald spot is growing rapidly. No loose hairs.

Observation period after interruption of treatment: approximately 1 month.

VII. Holger V.-S., 50 years old, cigar dealer. Started on 8/11 98.

History: He believes he was infected by an acquaintance who had pelade décalv. The current spot has grown slowly over a period of 2-3 months.

Status praes: Round spot with a diameter of 3 cm on the left temple. Loose hairs at the edge. No bulbous thickening of the hairs

Treatment started: November 8, 1998.

Treatment ended: November 12, 1998 after 4 séances.

November 18, 1998. Clear downy hairs on the entire patch.

November 26, 1998. Lively hair growth all over the patch. The hairs are still unpigmented. The patch has not increased in size. No loose hairs.

December 20, 1998. Good hair growth on the entire patch that has not grown. No loose hairs anywhere. The hairs are always unpigmented.

Observation period after the interruption of treatment: 5 weeks.

I will make the comments I would like to make on the above-mentioned case reports as brief as possible

To turn immediately to what I consider to be the most convincing and illustrative case, I will highlight Case Report II. The affliction, which is only about one month old, is nevertheless quite extensive, and it is further stated that it is in continuous propagation. When the patient, who had been absent from the light clinic for about 412 months, was referred for examination, the light-treated areas (spots 2, 3, and the anteriormost edge of spot 1) were healed, while the untreated posterior part of spot 1 had widened. This seems to prove that the affliction, despite its undeniable tendency to propagate, was brought to a standstill and recovery directly by the treatment, and further conviction—I might almost say, of the specific effect of the light treatment—is gained , — by this

that the remaining part of the disease also responds to the treatment. The long intervals between revisions due to the patient's unreliability prevent an observation of how quickly the recovery occurred in this case, but emphasize all the more clearly the contrast between treatment and non-treatment.

In the instructive case report III, it seems more convincing to me that the new spots (3, 4, and 5) are covered with hair 17 days after the treatment was discontinued than that the original disease (spots I and 2) was relieved 13 days after the treatment was completed, and barely 3 weeks after the patient appeared at the light clinic. For the cessation of the original disease, which was already three months old, could at times, albeit somewhat forcedly, be explained as a result of spontaneous recovery, to which alopecia areata is prone, whereas this cannot really be assumed with regard to the infection that arose later

On the whole, all cases show an unexpectedly rapid reaction with regard to hair growth. In Case Report I, we see lanugo hair 12 days after treatment was discontinued (i.e., 1 month after the start of the course), and normal hair growth after about 2 months. The small recurrence in loco mentioned in this Case Report was already covered with fine hair 10 days after it was diagnosed and treated.

The longest period of recovery (2.5 months) is found in Case Report IV. The affection is, after all, very widespread here and constantly spreading; in addition, one must note an interruption in treatment of 16 days due to a femoral lesion.

The shortest reaction time is in Case Report VII, where downy hairs are present on the patch 6 days after the end of treatment and 10 days after the start of the course.

The club-like thickening of the hair mentioned by Sabouraud, the presence of which indicates that the condition is spreading, was present in three of the cases; loose hairs in the edges are noted in four of the case reports. In five of the anamnesis, it is stated that the patients themselves noticed the continued growth of the patches.

Recurrence in loco is found only in case one (Case Report I). The patches that reappeared at other locations on the head in Case Report III cannot be attributed to the light treatment, at most to the general antiseptic treatment of the scalp.

The longest observation period with regard to recurrences after the cessation of treatment is 8-9 months (Case Reports I, II, and III).

The only time an accident occurred during treatment was in Case Report I, where a small burn left permanent baldness. In all other cases, the local reaction did not exceed the limits of the desired, superficial dermatitis. As with the other treatment methods and with spontaneous recovery from the condition, the first hairs to appear are fine, unpigmented lanugo hairs. The pigment deficiency can persist even after the hairs have regained their normal shape (e.g., in Case Report V). The hairs in Case Report II have undergone a very peculiar change, where their color is gray, even after they are completely identical in length and thickness to the other black hairs. The explanation can only be sought in the patient's age (52 years). Finsen's Medical Light Institute. 9

The disease has certainly affected the hair papillae in such a way that the regenerated hairs have prematurely achieved the venerable color which the onset of senility only imparts to the other head hairs somewhat later.

I cannot comment on how the treatment affects the very widespread forms (decaying hair). I hope that these forms, which arise from the growth and confluence of scattered patches, can be avoided by early treatment of the individual propagating alopecia.

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